Stormwater Best Management Practices

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M A N U A L

City of Chattanooga

Stormwater Best Management Practices Manual

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City of Chattanooga

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1. Purpose, Applicability, and Scope

This Best Management Practices (BMP) manual is a support document for an evolving stormwater management program. The latest version has been designed and structured to be a "living document" that grows, evolves, and matures along with the program it supports. It represents the current practice and state of art of the stormwater management program in the Chattanooga metropolitan area. As a supporting and largely technical document, the manual provides guidance to the implementation of an effective stormwater management program.

"Quantity follows Quality." Promote and control water quality as a first priority and water quantity control will be accomplished in the proper context. Water quantity (flooding) control at the local government level should focus on the control of more frequent storm events. The BMP Manual is consistent with this philosophy. Additionally, the manual serves as a tool for local government compliance with National Pollutant Discharge Elimination System (NPDES) stormwater rules.

It is the purpose and intent of the BMP Manual to provide the user and practitioner with a viable selection of approved and effective means to meet local legal requirements for stormwater management.

The BMP Manual is designed to be universally adaptable and used by local governments with their own appropriate regulatory program. While the manual could be utilized in other parts of the U.S. with similar terrain and hydrology, it is the intent for this manual to be used within Chattanooga Metropolitan Planning Area.

The manual covers the application of BMP for construction activity and property development. The manual is not an enforcement document but rather a technical guide to the proper selection and use of various physical constructs or BMP is designed to meet the governing requirements in the applicable jurisdiction.

The construction activity-related BMP are selected to be universally applicable to the entire Chattanooga Metropolitan Planning area. Property site development controls, however, are the purview of each local jurisdiction wherein compliance and regulatory programs may differ.

The BMP Manual is designed to provide measures for compliance within the context of current jurisdictional rules but it also contemplates a greater degree of engineering sophistication for an evolving storm water management program. The development and maintenance of calibrated hydrologic/water quality models for each basin is

necessary before true performance-based controls are appropriate and relationships can be made to the "total maximum daily loading" (TMDL) requirements that will become the compliance measure for local stormwater management. Until then, generalized performance measures and certain minimum controls are the option of choice.

Water quality control in Chattanooga is enforced through a permit program that requires the development and implementation of a "stormwater pollution prevention plan" (SWPPP) modeled after Tennessee's corresponding and applicable permit program. Permit compliance like the State's permit program is assessed based on the utilization of certain BMPs and the visible character of discharges from storm events. The BMP Manual provides a choice of acceptable practices that can be specified as required controls applicable to the respective permit.

Chattanooga landscape requirements are included in the appendices and are considered a part of the BMP manual for satisfying water quality and water quantity minimums for property development.

Local legislation specifies the minimum controls and performance criteria for water quantity and water quality control. In that regard, Chattanooga's regulatory program for property development is limited to its jurisdiction. Current requirements of the Chattanooga program are specified by ordinance included in the appendices.

2. BMP Guidelines

Current engineering and construction standards applicable to each jurisdiction remain. This manual for Best Management Practices (BMP) does not create new construction standards except as applicable to specific BMP. Graphic and technical information for approved BMP as well as proper application techniques are included. Performance may vary widely depending on site-specific activities and conditions. The information provided within this manual is for illustrative purposes and as a general aid to the proper application of construction controls. It is not intended as a substitute for professional engineering judgment or practice.

The applicable local or state permit defines performance standards. Applicable local or state permits may specify the water discharge limitations for quantity and quality. For example, a limit and/or range may be specified for indicator parameters such as turbidity, color, pH, and oil.

Application and Use of BMP

The BMP described herein are approved methods to be used to adequately control construction-related erosion, sedimentation, and water and airborne pollutant releases from construction sites. These BMP are to be utilized to satisfy the development of an "Erosion and Sedimentation Control Plan" or the conditions of a "Construction Activity Permit" as applicable. The effectiveness of the BMP in any application depends on the proper use, construction, and maintenance of the BMP and is subject to certain performance criteria as defined by the "Construction Activity Permit" or applicable local ordinance.

There are many factors that must be considered in the proper selection and successful application of BMP. The BMP fall into two basic classes, preventative measures and containment measures. Preventive measures are typically more effective of the two and entail those practices which eliminate or minimize exposure while containment measures are directed at capturing and controlling released sediment and pollutants. For example, dust control through water spraying of exposed surfaces or use of stone and gravel is a preventive measure. The descriptions of each of the BMP in this manual are characterized as to whether they are primarily preventive or containment types.

Certain factors are key to successful pollution control and should be addressed in a plan of control. A brief discussion of these factors follows.

Stabilization of Denuded Areas and Soil Stockpiles

Soil stabilization measures protect soil from the erosion forces or raindrop impact, flowing water, and wind. Soil stabilization is a preventive measure and one of the more effective measures. Applicable practices include ground cover preservation, vegetative establishment, mulching, surface treatments, surface cover, and early use of stone/gravel in areas to be paved.

When larger areas are left bare or unprotected, containment measures such as sediment basins in addition to other appropriate BMP measures may be necessary.

Protection of Adjacent Properties

Properties adjacent to the construction site must be considered in any control plan. Care must be taken to prevent increased water flow and sediment deposition on adjacent properties. A variety of measures may need to be considered to properly control runoff. Typically, no one control measure will suffice. In most cases, both preventive and containment measures must be utilized.

Persons engaged in construction activity, property development, or property management should also be aware of civil law and legal precedents governing the discharge and or alteration of the flow onto or from adjoining properties. Generally, the rule is “cause no harm.”

Protection of Waterways and Outlets

On-site stormwater conveyance channels, both temporary and permanent, must be designed and constructed in a way to prevent erosion of the channel and any connecting conveyance. In addition, existing and new storm sewer inlets must be protected to prevent sediment deposition.

Construction-related activity should not encroach or adversely impact existing water courses or floodways. In addition, care should be exercised in flood prone areas to prevent filling and obstructions that may increase flood levels or exacerbate scour or erosion.

Special care should also be exercised with regard to sinkholes and wells, which may provide source waters for drinking and healthy streams.

Construction Planning and Management

The responsibility to control erosion, sediment transport, and stormwater pollution from a construction site requires a comprehensive plan. Elements of the plan include

consideration for factors that minimize the exposure of soils and pollutants such as debris, oils, and construction materials to rain or wind. Site selection that minimizes the degree of difficulty in controlling erosion is the first consideration in any successful plan of development.

Preventive measures such as construction planning, sequencing, scheduling, and timing to reduce exposure can greatly minimize the degree of difficulty. In any event, containment measures must be in place prior to the start of construction activities that create exposure. It is also essential that the planning and management of the site include the proper maintenance of all BMP.

Roadwork and Pavement Construction

Roadwork and pavement construction activities create significant pollution problems and require special considerations to minimize and prevent occurrences. Preventative and containment measures are usually required. These measures may include the following:

- Cover storm drain inlets and manholes when paving or applying paving materials and coatings.
- Apply concrete, asphalt, and coatings during dry weather to prevent contaminant releases.
- Park paving machines and equipment over drip pans or absorbent materials to capture and properly dispose of fluids and equipment-released pollutants.
- Use limited amounts of water when sawing or milling pavement. Protect all affected catch basins through appropriate measures, i.e., filter bags, inlet sediment traps, etc., and remove and reuse or properly dispose of all accumulated slurry, residue and sediment from the gutter, pavement, and inlet traps.
- Wash down exposed concrete aggregate only when the wash water can (1) flow onto an absorbent soil area and (2) drain into a capture basin that can be pumped and reused or properly disposed. Concrete truck wash-down waters should be reused. A single truck chute wash may direct into a properly selected and prepared on-site hole.
- Never wash sweepings from exposed aggregate concrete into a street or storm drain. Materials should be reused or properly disposed to prevent water and airborne contamination.
- Broken concrete and asphalt should be recycled.

BMP Descriptions

The BMP descriptions included in this manual are not exhaustive and do not include every BMP that may be employed for construction site management. This manual describes those measures that have come into common practice and have been found to be effective when properly applied and maintained. Additional BMP may be included as this manual is updated.

3. Erosion and Pollution Control Plan

What is an Erosion and Pollution Control Plan?

An Erosion and Pollution Control Plan (EPCP) is a document that recognizes the potential for water quality impacts on a construction project and provides an illustrated plan of action and measures to control and mitigate water pollution impacts.

The EPCP is a stand-alone document. Specifications for the EPCP may be incorporated into construction documents but must have the ability to be separated and still provide complete construction activity measures for controlling water pollution. An EPCP is mandatory in the City of Chattanooga.

What is an Adequate Plan?

An EPCP must contain sufficient information to satisfy the local and state stormwater management agency that effective and adequate measures are in place for the proposed construction activity. Detail and complexity should be commensurate with the scale and scope of the construction activity or project as well as the severity of site conditions and sensitivity of the surrounding environment.

Ultimately, the adequacy of the plan will be measured against its effectiveness. Current state and some local government standards specify measurable parameters, which are enforced through a permit program. The judicious and liberal use of the BMP described in this manual provides the proper tools for an adequate plan.

Standards and Specifications

This manual describes recommended and approved standards and specifications for BMP. The application of these BMP in any EPCP should be clearly identified and noted on any document or plan sheet. The symbology shown in this manual should be used as a graphic and communication aid that can simplify and make the plan development process more efficient. This coding system minimizes the need for certain details and promotes uniformity in plan documents.

Modifications or alternative BMP may also be employed but may require the prior approval of the local governing jurisdiction.

Responsibility for Plan Preparation and Implementation

Responsibility for the preparation and implementation of the plan rests with the property owner or developer. The owner/developer may designate an engineer to prepare the plan and a contractor to implement the plan, but the responsibility remains with the owner/developer.

Plan Enforcement

Plan enforcement is through a permit program administered by the state, and in most cases, by a local stormwater agency. The efficacy of the EPCP is monitored by site inspection of the construction activity. The following list is typical of the items usually reviewed during a site inspection.

- Are BMP in place, adequate, and properly constructed?
- Have clearing operations been confined to the limits shown on the plan?
- Is vegetation outside of the designated cleared area protected and supplemented?
- Are sediment, debris, dust, oil, or other water contaminants being transferred from the site by vehicles, equipment, water, or wind?
- Is there evidence of erosion problems in the vicinity of stormwater management facilities?
- Are the BMP effective?
- Is appropriate vegetation being established as needed in specified areas?
- Is work progressing according to the planned schedule and sequence?
- Have necessary stream channel crossings been installed?
- Has topsoil been salvaged and stored as designated?
- Is there any fire hazard?
- Are BMP being maintained?
- What is the condition of water leaving the site?
- Are necessary stream buffers in place and protected?

4. BMP Specifications

4.1 Check Dam

CD

Definition

Small temporary barrier, grade control structure, or dam constructed across a swale, drainage ditch, or areas of concentrated flow.

Purpose

Check dams are used to minimize the erosion rate by reducing the velocity of stormwater in areas of concentrated flow.

Conditions

This practice is applicable for use in small open channels and is not to be used in a live stream. Specific applications include:

1. Temporary or permanent swales or ditches in need of protection during establishment of grass linings.

2. Temporary or permanent swales or ditches, which, due to their short length of service or other reasons, cannot receive a permanent non-erodible line for an extended period of time.

3. Other locations where small localized erosion and resulting sedimentation problems exist.

Design Criteria

Formal design is not required. The following standards shall be used.

Drainage Area

The drainage area of the check dam will not exceed 2 acres.

Height

The center of the check dam must be at least 9 inches lower than the outer edges. Dam height should be no more than 2 feet measured to center of check dam.

Sides Slopes

Side slopes shall not be steeper than 2 horizontal to 1 vertical (2:1).

Spacing

Two or more check dams may be required for drainage areas greater than 1 acre. Maximum spacing between dams should be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam.

Geotextiles

Suitable geotextiles should be placed between the rock and its soil base and abutments to prevent soil movement in the foundation and abutments.

Construction Specifications

The following types of check dams are used for this standard:

Stone Check Dams

Stone check dams should be constructed of graded 2- to 10-inch stone. See Figure 4.1.1. Mechanical or hand placement shall be required to ensure complete coverage of entire width of ditch or swale and that center of dam is lower than edges.

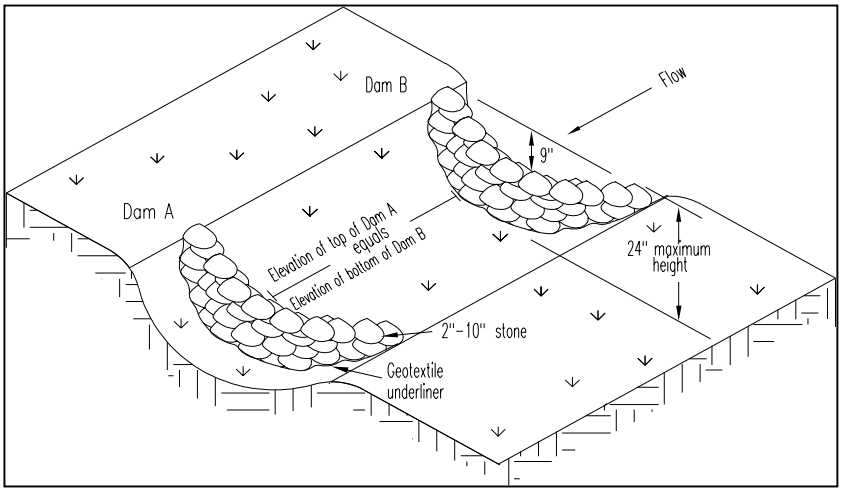


Figure 4.1.1 Stone Check Dam Installation Requirements

Haybale Check Dams

Staked and embedded haybales may be used as temporary check dams in concentrated flow areas while vegetation is becoming established. Haybales should not be used where the drainage area exceeds 1 acre and must be embedded a minimum of 4 inches. See Figure 4.1.2.

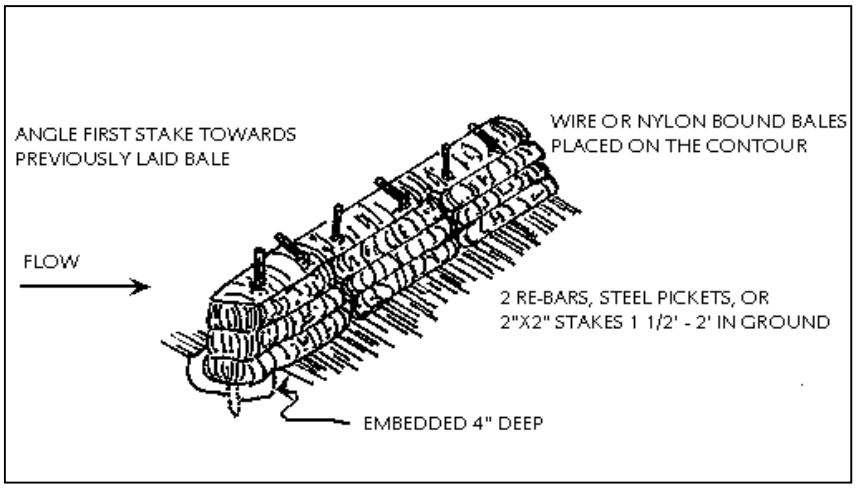


Figure 4.1.2 Straw Bale Barrier Installation Requirements

Maintenance

Periodic inspections and regular maintenance must be provided. Sediment should be removed when it reaches a depth of one-half the original dam height or before. Check dams must be removed at the completion of their useful life. After removal, the area beneath the dam should be seeded and mulched immediately.

4.2 Channel Stabilization

CH

Definition

Improving, constructing, or stabilizing an open channel for water conveyance.

Purpose

Open channels are constructed or stabilized to be non-erosive with no sediment deposition and to provide adequate capacity for flood water, drainage, other water management practices, or any combination thereof.

Conditions

This standard applies to the improvement, construction, or stabilization of open channels and existing streams or ditches with drainage areas less than 1 square mile.

An adequate outlet for the modified channel length must be available for discharge by gravity flow. Construction or other improvements of the channel should not adversely affect the environmental integrity of the area and must not cause significant erosion upstream of the flooding and/or sediment deposition downstream. Channel modifications are subject to local and state regulatory requirements.

Design Criteria

Planning

During the alignment and design of channels, careful consideration shall be given to the preservation of valuable fish and wildlife habitat and trees of significant value for wildlife food or shelter or for aesthetic purposes.

Where channel construction will adversely affect significant fish or wildlife habitat, mitigation measures must be included in the plan. Mitigation measures may include pools, riffles, flats, cascades, or other similar provisions.

As many trees as possible are to be left inside channel rights-of-way considering the requirements of construction, operation, and maintenance. Unusually large or beautiful trees shall be saved.

Realignment

The realignment of channels shall be kept to an absolute minimum and should be permitted only to correct an adverse environmental condition.

Channel Capacity

The capacity for open channels shall be determined by procedures applicable to the purposes to be served.

Hydraulic Requirements

Manning's formula shall be used to determine velocity in channels. The "n" values for use in this formula shall be estimated using currently accepted guides along with knowledge and experience regarding the conditions. Acceptable guides can be found in hydrology textbooks.

Channel Cross Section

The required channel cross section and grade are determined by the design capacity, the materials in which the channel is to be constructed, and the requirements for maintenance. A minimum depth may be required to provide adequate outlets for subsurface drains and tributary channels.

Channel Stability

All channel construction, improvements, and modifications shall be in accordance with a design expected to result in a stable channel that can be maintained. Characteristics of a stable channel include:

1. The channel neither aggrades nor degrades beyond tolerable limits.

2. The channel banks do not erode to the extent that the channel cross section is changed appreciably.

3. Excessive sediment bars do not develop.

4. Excessive erosion does not occur around culverts, bridges, or elsewhere.

5. Gullies do not form or enlarge due to the entry of uncontrolled surface flow to the channel.

6. The determination of channel stability considers "bankfull" flow. Bankfull flow is defined as flow in the channel, which creates a water surface that is at or near normal ground elevation for a significant length of a channel reach. Excessive channel depth created by cutting through high ground should not be considered in determinations of bankfull flow.

Channel Linings and Structural Measures

Where channel velocities exceed safe velocities for vegetated lining due to increased grade or a change in channel cross section, or where durability of vegetative lining is adversely affected by seasonal changes, channel linings or rock, concrete, or other durable material may be needed. Grade stabilization structures may also be needed. Channels may be stabilized by the following methods:

Rock Riprap Lining

Rock riprap shall be designed to resist displacement when the channel is flowing at the bankfull discharge or 25-year frequency discharge, whichever is less. Dumped and machine-placed riprap should not be installed on slopes steeper than 1½ horizontal to 1 vertical.

A filter blanket of sand and/or gravel or geotextile material shall be placed between the riprap and base material. The filter blanket material shall be at least 6 inches thick with a gradation that is consistent with the base material and the riprap.

Rock shall be dense, resistant to the action of air and water, and suitable in all other respects for the purpose intended. Rock shall be installed according to applicable standards.

Concrete Lining

Concrete lining shall be designed according to currently accepted guides for structural and hydraulic adequacy. Concrete lining must be designed to carry the required discharge and to withstand the loading imposed by site conditions. Concrete lining should be considered only for extreme conditions and if approved by governing agencies. Generally, channel velocities exceeding 14 feet per second (ft/sec) may be considered for this approach.

Grade Stabilization Structures

Grade stabilization structures are used to reduce or prevent excessive erosion by reducing velocities in the watercourse or by providing structures that can withstand and reduce the higher velocities. Structures may be constructed of concrete, rock, masonry, steel, aluminum, or treated wood.

These structures are constructed where the capability of earth and vegetative measures is exceeded in the safe handling of water at permissible velocities, where excessive grades or overall conditions are encountered, or where water is to be lowered structurally from one elevation to another. These structures should be planned and installed along with or as a part of other erosion control practices.

The structures must be designed hydraulically to adequately carry the channel discharge and structurally to withstand loadings imposed by the site conditions.

Installation Requirements

1. When necessary, trees, brush, stumps, and other objectionable materials may be removed so they will not interfere with the construction or proper functioning of the channel.

2. Where possible, trees will be left standing and stumps will not be removed.

3. Excavation shall be at the locations and grades shown on the drawings.

4. Construction plans will specifically detail the location and handling of spoils. Spoil material resulting from clearing, grubbing, and channel excavation shall be disposed in a manner which will:

    a. not cause an increase in flood stage,

    b. minimize overbank wash,

    c. not cause an adverse effect of the environmental integrity of the area,

    d. provide for the free flow of water between the channel and flood plain unless the valley routing and water surface profile are based on continuous dikes being installed,

    e. leave the right-of-way in the best condition possible, and

    f. improve the aesthetic appearance of the site to the extent feasible.

5. Channel linings shall be established or installed immediately after construction or as soon as weather conditions permit.

6. Structures shall be installed according to lines and grades shown on the plans. The foundation for structures shall be cleared of all undesirable materials prior to the installation of the structures.

7. Materials used in construction shall be of permanency commensurate with the design frequency and life expectancy of the facility.

8. When used as a part of the structures, earth fill shall be placed according to the installation requirements for sediment basin embankments.

9. Construction operations shall be executed in a manner that minimizes erosion and air and water pollution. Compliance with state and local laws concerning pollution abatement shall be maintained.

10. Vegetation shall be established on all disturbed areas immediately after construction, weather permitting. If weather conditions cause a delay in establishing vegetation, the area shall be mulched in accordance with the standards for mulching. Seeding, fertilizing, and mulching shall conform to the standard for permanent vegetative cover.

11. All temporary access roads or travel ways shall be appropriately closed to exclude traffic.

12. Trees or other fallen natural vegetation not causing a deterrent to stream flow should be left for the purpose of fish habitat.

13. Construction work in the stream should be performed only after consultation with and permitting by local government and the state environmental agencies.

4.3 Construction Exit

CO

Definition

A stone-stabilized pad located at any point where traffic will be leaving a construction site to a public right-of-way, street, alley, sidewalk, or parking area.

Purpose

Construction exits are used to reduce or eliminate the transport of mud from the construction area onto public rights-of-way by motor vehicles or by runoff.

Conditions

This practice is applied at appropriate points of construction egress. Geotextile underliners are required to stabilize and support the pad aggregates.

Design Criteria

Installation requirements for the construction exit are shown on Figure 4.3.1.

Aggregate Size

The aggregate size will be 1.5- to 3.5-inch stone in accordance with National Stone Association R-2.

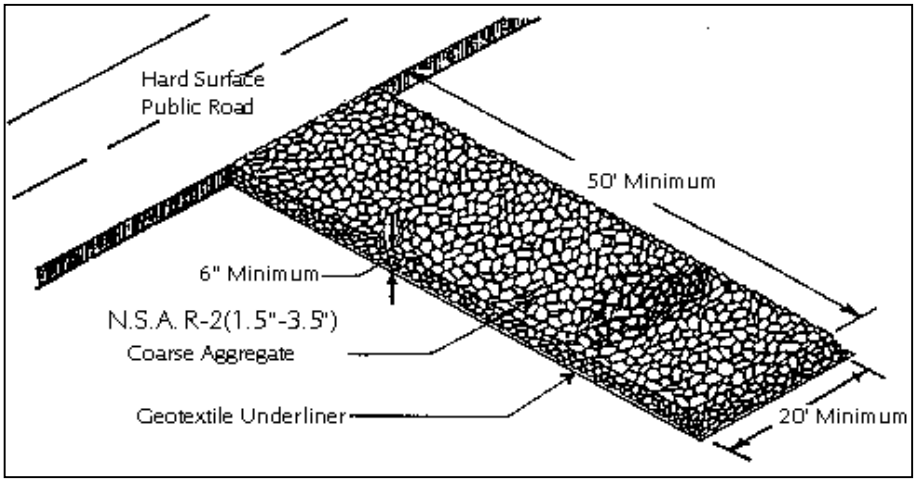


Figure 4.3.1 Crushed Stone Construction Exit Installation

Pad Thickness

At a minimum, pad thickness should be 6 inches.

Pad Width

At a minimum, pad width should equal the full width of all points of vehicular egress but not less than 20 feet wide.

Washing

Wheels must be cleaned to remove mud prior to entrance onto public rights-of-way. When required, washing shall be done on an area stabilized with crushed stone, which drains into an approved sediment trap or sediment basin.

Location

The exit shall be located to prevent sediment from leaving the site.

Maintenance

The exit shall be maintained in a condition that will prevent tracking or flow of mud onto public rights-of-way. This may require periodic top dressing with 1.5- to 3.5-inch stone, as conditions demand, and repair and/or cleanout of any structures to trap sediment. All materials spilled, dropped, washed, or tracked from vehicles or site onto roadways or into storm drains must be removed immediately.

Construction Specifications

It is recommended that the entrance area be excavated to a depth of 3 inches and be cleared of all vegetation and roots. Filter fabric underliner must be placed the full length and width of the entrance. See Figure 4.3.2.

Figure 4.3.2 Geotextile Liner Under Gravel

4.4 Diversion

DI

Definition

A ridge of compacted soil, constructed above, across, or below a slope.

Purpose

Diversions are used to reduce slope lengths and intercept and divert storm runoff to a stable outlet at a non-erosive velocity.

Conditions

The use of diversions is applicable when:

1. Runoff from higher areas has potential for damaging property, causing erosion, contributing to pollution, flooding, and/or interfering with or preventing the establishment of vegetation on lower areas.

2. Surface and/or shallow subsurface flow is damaging slope upland.

3. The length of slope should be reduced to minimize soil loss.

This standard applies to temporary and permanent diversion structures used in development involving construction and surface-disturbing activities.

Design Criteria

Location

Diversion location shall be determined by considering outlet conditions, topography, land use, soil type, length of slope, seep planes (when seepage is a problem), and the development layout.

Design of Parabolic Grass-Lined Diversions

The peak runoff storm frequency to be used is shown in Table 4.4.1. The channel must be designed for capacity and stability. Capacity must be adequate to carry the peak runoff of the design storm when the grass is tall. The design for maximum permissible velocity shall be based on the height of the plant when mowed. Table 4.4.2 shows the maximum permissible velocity and retardant values for various vegetative covers.

TABLE 4.4.1

Diversion Design Criteria

Diversion Type	Land or Improvement Protected	Storm Frequency[1]	Freeboard	Minimum Top Width
Temporary	Construction areas Building sites	10 years[2]	0.3 foot	4 feet
Permanent	Landscaped, recreation and similar areas	25 years	0.3 foot	4 feet
	Dwellings, schools, commercial buildings, and similar installations	50 years	0.5 foot	4 feet

[1] Use 24-hour storm duration.
[2] Use 10 years or the storm frequency specified by applicable local and state regulatory code

TABLE 4.4.2

Permissible Velocities and Retardant Values for Vegetated and Rock-Lined Waterways

Vegetative Cover Type	Good Stand				Maximum Permissible Velocity V1 (ft/sec)
	For Capacity and V2		For Stability and V1		
	Retardant Value	Plant Height Not Mowed	Retardant Value	Plant Height Mowed	
Bermuda Grass	B	12”	D	2-6”	5
Bahia	C	6-12”	D	2-6”	4
Tall Fescue Grass Mixtures[1]	B	18”	D	6”	4
Sericea Lespedeza Weeping Lovegrass	B	19”	D	2-6”	3

[1] Mixtures of Tall Fescue, Bahia, and/or Bermuda.

NOTE: For planting instructions, refer to "Disturbed Area Stabilization (With Permanent Vegetation)."

This approach provides a channel design having capacity for tall unmowed grass with a velocity V2. The velocity V1, for the mowed height, should not exceed that shown in Table 4.4.2. Professional engineering assistance may be required.

Cross Section

The channel portion of the diversion may be parabolic or trapezoidal. The compacted ridge shall be designed to have stable side slopes, which will not be steeper than 2:1. The ridge shall be minimum width of 4 feet at the design water elevation after settlement. Ten percent should be allowed for settlement.

Channel Dimensions

Diversions should be tailored to fit the conditions of a particular field and local soil type(s). Velocities should be kept as high as will be safe for the planned type of cover and the expected maintenance. Table 4.4.2 may be used as a guide in selecting design velocities.

Land slope must be taken into consideration when choosing channel dimensions. On the steeper slopes, narrow and deep channels may be required. On the more gentle slopes, broad, shallow channels are typically applicable. Wide, shallow channels are easier to maintain.

Size of Channel

After "Q" (the flow), the channel grade and the safe velocity have been calculated, the required size of diversion channel can be determined from established engineering practices.

Outlets

Each diversion must have an adequate outlet. The outlet may be a constructed or natural waterway, a stabilized vegetative area, or a stabilized open channel. In all cases, the outlet must discharge in such a manner as to not cause an erosion problem. Protected outlets shall be constructed and stabilized prior to construction of the diversion.

Stabilization

Channels shall be stabilized in accordance with Item 5 of the construction specifications on page 4.6.

Roads and Utility Rights-of-Way

Diversions installed to divert water from a road or right-of-way shall consist of a series of compacted ridges of soil running diagonally across the road at a 30-degree angle. Ridges are constructed by excavating a channel upstream for this type of diversion.

A detailed design is not required for this type of diversion. The compacted ridge heights shall be 8 to 12 inches above the original road surface. See Figure 4.4.1. Channel bottoms and ridge tops should be smooth enough to be crossed by vehicular traffic. Stable outlets must be provided for each diversion. The maximum recommended spacing between diversions is as follows:

Road Grade (percent)	Distance Between Diversions (feet)
1	400
2	250
5	125
10	80
15	60
20	50

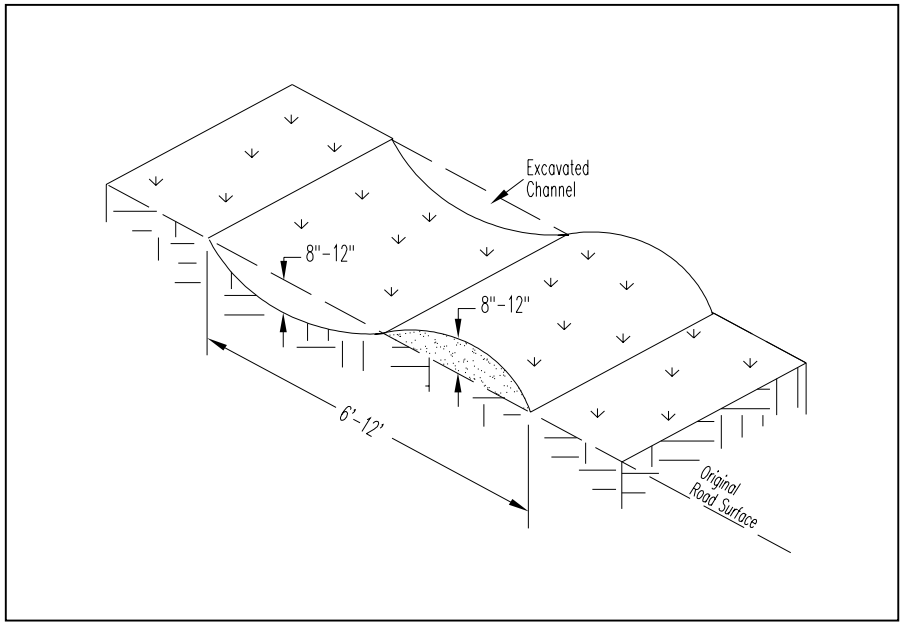


Figure 4.4.1 Typical Diversion Across Road

Construction Specifications

1. Trees, brush, stumps, obstructions, and other objectionable material may be removed and disposed of so as not to interfere with the proper functioning of the diversion.

2. The diversion shall be excavated or shaped to line, grade, and cross section as required to meet the criteria specified herein and free of irregularities that will impede normal flow.

3. When necessary, fills shall be machine-compacted to prevent unequal settlement that would cause damage in the completed diversion.

4. All earth removed and not needed in construction shall be spread or disposed of so that it will not interfere with the functioning of the diversion.

5. Stabilization

    a. Vegetative Protection

        i. The appropriate standard and specification of this manual shall be followed for disturbed area stabilization for time of seeding, sprigging or sodding, liming and fertilizing, and site and seedbed preparation.

        ii. Mulching shall be required for all seeded or sprigged channels and shall be performed at rates shown in "Disturbed Area Stabilization (With Mulching Only)."

        iii. Temporary protection during establishment should be provided when conditions permit the use of temporary diversions or other means to dispose water.

    b. Mechanical Vegetative Protection

        Stone center diversions may be stabilized with riprap in accordance with accepted engineering practices.

    c. Mechanical Protection

        Paving shall be performed in accordance with the Department of Transportation specifications for paved ditches.

4.5 Temporary Downdrain Structure

Dn1

Definition

A pipe used as a temporary structure to convey a concentration of stormwater down the face of cut or fill slopes.

Purpose

Temporary downdrain structures are used to safely conduct storm runoff from one elevation to another without causing slope erosion.

Conditions

Temporary downdrains are used on slopes where a concentration of stormwater could cause erosion damages. These structures are removed once the permanent water disposal system is installed.

Design Criteria

Placement

Downdrain structure shall be installed on undisturbed soil or well-compacted fill.

Diameter

Sufficient capacity is required to convey the maximum runoff expected during the life of the drain.

Downdrain Inlet and Outlet

Use a Tee or "L" inlet at the top of the slope. Slope the entrance ½ inch per foot toward the outlet. Thoroughly compact selected soil around the inlet section to prevent the pipe from being washed out by seepage or piping. Stabilize the outlet section, a Tee outlet, rock riprap, or other suitable material. See Figure 4.5.1.

Pipe

Design the slope drain using heavy-duty, flexible materials such as non-perforated, corrugated plastic pipe or specially designed flexible tubing. Use reinforced, hold-down grommets or stakes to anchor the pipe at intervals not to exceed 10 feet with the outlet end securely fastened in place. The pipe must extend beyond the toe of the slope.

TABLE 4.5.1

Pipe Diameter for Temporary Downdrain Structure

Maximum Drainage Area per Pipe (acre)	Pipe Diameter (inches)
0.3	10
0.5	12
1.0	18

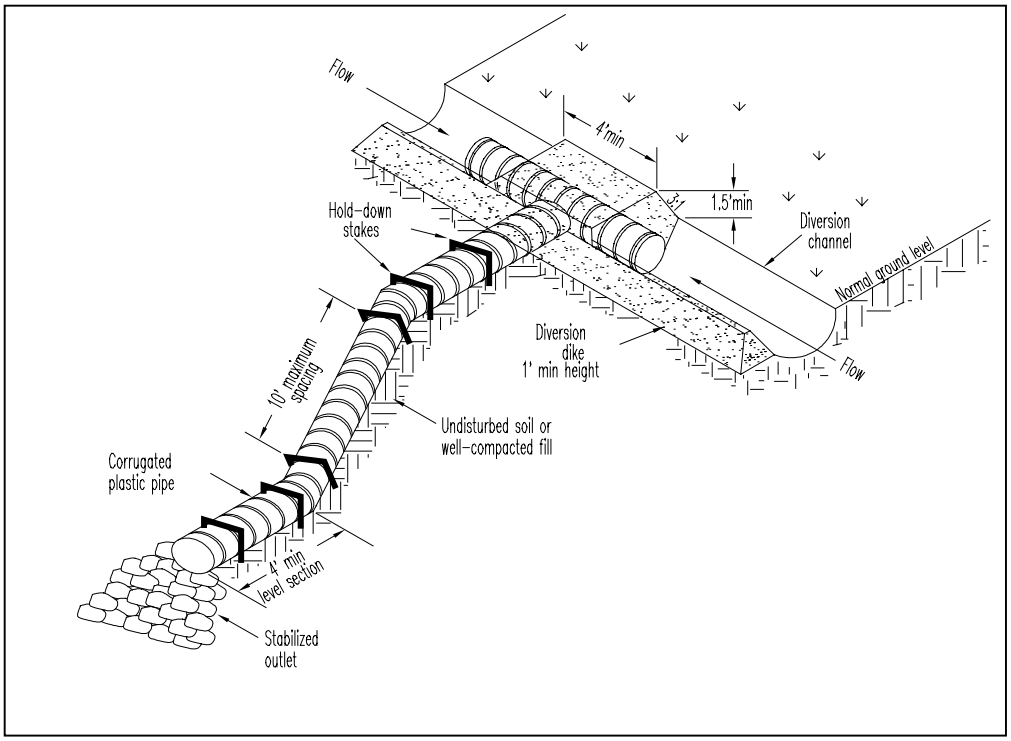


Figure 4.5.1 Temporary Downdrain and Inlet Detail

Construction Specifications

A common failure of slope drains is caused by water saturating the soil and seeping along the pipe. This creates voids from consolidation and causes washouts. Proper backfilling around and under the pipe "haunches" with stable soil material and hand compacting in 6-inch lifts to achieve firm contact between the pipe and the soil at all points will eliminate this type of failure.

1. Place slope drains on undisturbed soil or well-compacted fill at locations and elevations shown on the plans.

2. Slightly slope the section of pipe under the dike toward its outlet.

3. Hand tamp the soil under and around the entrance section in lifts not to exceed 6 inches.

4. Ensure than fill over the drain at the top of the slope has minimum dimensions of 1.5-foot depth, 4-foot top width, and 3:1 side slopes.

5. Ensure that all slope drain connections are watertight.

6. Ensure that all fill material is well compacted. Securely fasten the exposed section of the drain with grommets or stakes spaced no more than 10 feet apart.

7. Extend the drain beyond the toe of the slope and adequately protect the outlet from erosion.

8. Make the settled, compacted dike ridge no less than 1 foot above the top of the pipe at every point.

9. Immediately stabilize all disturbed areas following construction.

Maintenance

Inspect the slope drain and supporting diversion after every rainfall and promptly make necessary repairs. When the protected area has been permanently stabilized, temporary measures may be removed, materials disposed of properly, and all disturbed areas stabilized appropriately.

4.6 Gabion GA

Definition

Gabions are large, multi-celled, welded wire or rectangular wire mesh boxes, used in channel revetments, retaining walls, abutments, and check dams.

Purpose

Rockfilled baskets, properly wired together, form flexible monolithic building blocks used for construction of erosion control structures. Gabions are used to stabilize steep or highly erosive slopes.

Design Criteria

Construction plans and drawings should be prepared by professionals familiar with the use of gabions. Erosion and sediment control construction design should ensure that foundations are properly prepared to receive gabions, that the gabion structure is securely "keyed" into the foundations and abutment surfaces, and that rock used is durable and adequately sized to be retained in the baskets.

Construction Specifications

How the Gabion is Filled

The gabion is normally filled with hand-sized 4- to 8-inch pieces of stone, usually dumped into the basket mechanically. The filled gabion then becomes a large, flexible and permeable building block from which a broad range of structures may be built. This is done by setting and wiring individual units together in courses and filling them in place.

Corrosion Resistance of Gabions

The wire mesh or welded wire used in gabions is heavily galvanized. For highly corrosive conditions, a polyvinyl chloride (PVC) coating must be used over the galvanizing. Such treatment is an economical solution to deterioration of the wire near the ocean, in some industrial areas, in polluted streams, and in acidic soils such as muck and peat.

Flexibility

An outstanding advantage of the gabion is its flexibility. This property is especially important when a structure is on unstable ground or in areas where scour from waves or currents can undermine it.

Durability

Gabions are durable because they support plant growth, which develops a living coating for the wire mesh and stones. Frequently, the wire basket is only needed for the first few years, because the voids between the individual stones fill with soil, silt, and roots, which act as a bonding agent for the stones.

Strength

Steel wire baskets have the strength and flexibility to withstand forces generated by water and earth masses. The pervious nature of the gabion allows it to absorb and dissipate much of the energy developed. A compact gabion structure may remain long after a massive rigid structure fails.

Permeability

Hydrostatic heads do not develop behind the gabion wall. The wall is pervious to water and stabilizes a slope by the combined action of draining and retaining. Drainage is accomplished by gravity and by evaporation as the porous nature permits air circulation through the structure. Moreover, as plant growth invades the structure, transpiration further assists in removing moisture from the backfill. This system is much more efficient than weep holes in standard masonry walls.

Economy

Gabion installations are more economical than rigid or semi-rigid structures for a number of reasons. The following are among the more important ones.

- Little maintenance is required.
- Gabion construction is simple and requires no skilled labor.
- Preliminary foundation preparation is unnecessary. The surface needs only to be reasonably level and smooth.
- Since gabions are porous, no costly drainage provision is required.

Landscaping

Because gabions permit the growth of natural vegetation and maintain the natural environment of the area, they provide attractive and natural building blocks for decorative landscaping.

Gabions can be used effectively and economically in parks, along highways, and around bridge approaches to create walkways, rock gardens, patios, and terraces. Not only can gabions improve property aesthetics, beautifying the banks of lakes and ponds and accenting trees and other plantings, they can be used as successful sound barriers. The application of gabions in decorative landscaping is limited only by the ingenuity of the landscaper. Typical installations include:

- River Training and Flood Control
  - Gabion Aprons
  - Longitudinal Works
  - Training Walls
  - Revetments
  - Bank Paving
  - Counterforts
  - Drop Structures or Weirs
  - Spurs, Spur Dikes, or Groins
- Channel Linings
- Retaining Walls
- Bridge Abutments and Wings
- Marinas and Boat Ramps
- Culvert Headwalls and Outlet Aprons
- Shore and Beach Protection

Maintenance

Periodic inspections should be performed for signs of undercutting or excessive erosion at transition areas.

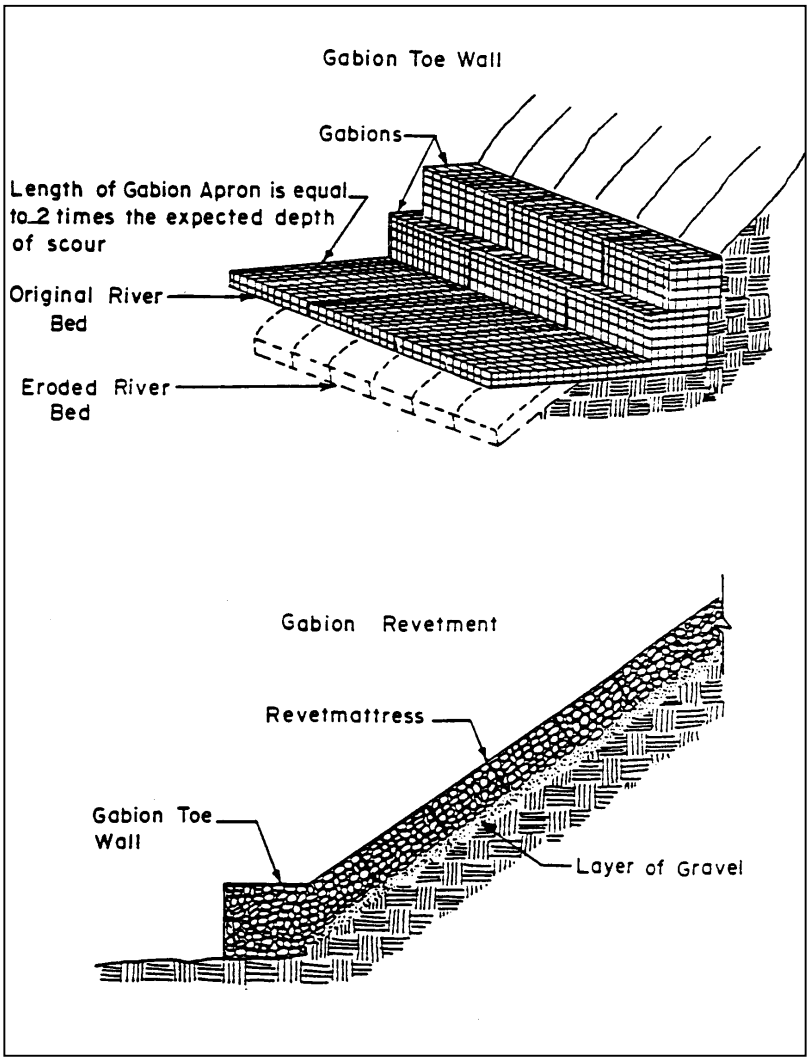


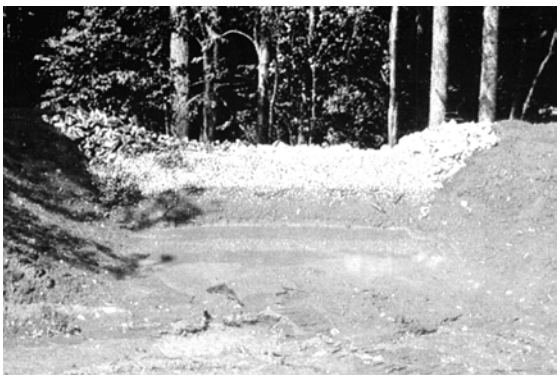
Figure 4.6.1 Gabion Typical

4.7 Rock Filter Dam

RdA

Definition

Permanent or temporary stone filter dam installed across streams or drainageways.



Purpose

A rock filter dam is installed to serve as a sediment-filtering device in drainage ways. In some cases, the structure may reduce the velocity of stormwater flow through a channel. The rock dam is not intended to substantially impound water.

Conditions

This practice is applicable for use in small channels that drain 50 acres or less. To reduce the amount of sediment reaching the channel, rock filter dams must be used in conjunction with other appropriate sediment control measures. Specific applications include:

1. Use as an additional sediment control measure below construction projects such as culvert installations, dam construction, or any project that may involve grading activity directly in a stream.

2. Use at the upstream end of ponds or lakes to trap incoming sediment loads.

Before structures of any kind are installed in streams, the appropriate agencies and local officials should be contacted.

Design Criteria

It is recommended that a qualified engineer be consulted before any structure is installed in a flowing stream. Installation requirements are shown on Figure 4.7.1. The following standards must be followed:

Drainage Areas

Drainage areas shall not exceed 50 acres.

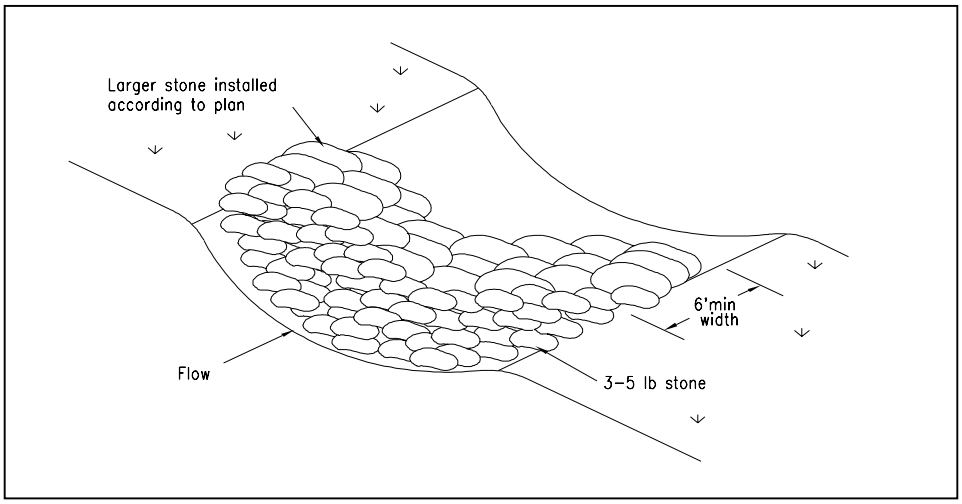


Figure 4.7.1 Rock Filter Dam Installation Requirements

Height

The rock filter dam should not be higher than the channel banks or the level due to a 10-year, 24-hour storm or the storm specified by local ordinance. The center of the rock dam should be at least 6 inches lower than the outer edges of the dam at the channel banks.

Side Slopes

Side slopes shall be no steeper than 2:1.

Location

The rock dam should be located so that it will not cause water to backup on upstream adjacent property. Dam height should not exceed elevation of upstream property line.

Rock Size

Minimum rock size shall be determined by peak channel flow velocity per Table 4.7.1. The rock dam can be faced with smaller stone on the upstream side for additional filtering effect. Flow velocities in excess of 10 feet per second require a design prepared by a registered professional engineer and are subject to governing agency approval.

Top Width

The top width of the rock dam should be no less than 6 feet.

TABLE 4.7.1

Graded Riprap Stone

Flow Velocity (ft./sec.)	N.S.A. No.[1]	Size Inches			Filter Stone N.S.A. No.[1]
		Max.	Avg.[2]	Min.	
2.0	R-1	1½	¾	No. 8	FS-1
4.0	R-2	3	1½	1	FS-1
6.0	R-3	6	3	2	FS-2
8.0	R-4	12	6	3	FS-2
10.0	R-8	18	9	5	FS-2
12.0	R-6	24	12	7	FS-3
14.0	R-7	30	15	12	FS-3

[1] National Stone Association

[2] At least 50% of the individual stone particles must be equal or larger than this listed size.

Construction Specifications

Mechanical or hand placement will be required to ensure that the rock dam extends completely across the channel and securely ties into both channel banks. To serve as a type of weir, the center of the dam must be no less than 6 inches lower than the sides. Gabions can be installed to serve as rock filter dams but recommended sizing and installation specifications must be followed.

Maintenance

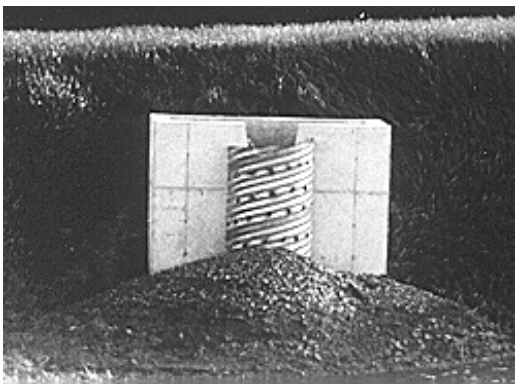
Rock dams should be removed at the completion of their useful life. Periodic inspection and required maintenance must be provided. Sediment should be removed when it reaches a depth of one-half of the original height of the dam.

4.8 Retrofitting

Rt

Definition

A device or structure placed in front of a permanent stormwater detention pond outlet structure to serve as a temporary sediment filter.



Purpose

Retrofit structures allow permanent stormwater detention basins to function as temporary sediment retention basins.

Conditions

This standard applies under the following conditions:

1. Retrofitting cannot be used in detention ponds on live streams or in basins with a total contributing drainage area of 50 acres or more.

2. Can only be used in detention basins large enough to store 67 cubic yards of sediment per acre of disturbed area in the project. Required sediment storage may be obtained by excavating in front of the retrofitted outlet structure.

3. Shall be considered a temporary structure and will be removed as soon as the project is completed. All accumulated sediment will be removed from the detention pond basin.

Design Criteria

1. The height of the retrofit should be approximately one-half of the height of the stormwater management outlet structure.

2. The required sediment storage volume shall be achieved by either excavating the basin or raising the outlet structure to achieve 67 cubic yards of sediment storage.

   This storage volume is exclusive of stormwater storage requirements. It is recommended that the sediment storage volume be based on total drainage area when possible. Remove sediment when the basin is one-third full.

3. For effective trapping efficiency, the sediment delivery inlets should be located at the upper end of the basin.

4. For effective trapping efficiency, the length-width ratio of the basin shall be at least 2:1. Flow length may be increased by installing baffle walls within the basin.

5. Drawings and computations prepared by a registered professional engineer shall be submitted for approval by the local governing agency.

Construction Specifications

The following types of structures are acceptable under the designated conditions:

1. Perforated Half-Round Pipe with Stone Filter (See Figure 4.8.1)

    a. Diameter of half-round pipe should be 1.5 times the diameter of the principal pipe outlet or wider than the greatest width of the concrete weir.

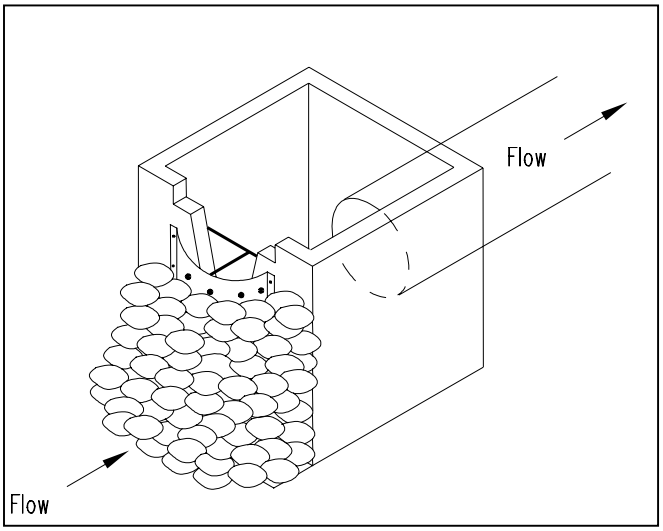


Figure 4.8.1 Perforated Half-Round Pipe Retrofit wit Stone Filter. See Figure 4.8.2 for an exploded view this structure.

    b. Perforations and stone sizes are shown in Figure 4.8.2.

    c. Shall be fixed by specified means (bolts, etc.) to concrete outlet structure but never used on exposed pipe end or winged headwall.

    d. Should be used only in detention ponds with less than 30 acres total drainage area.

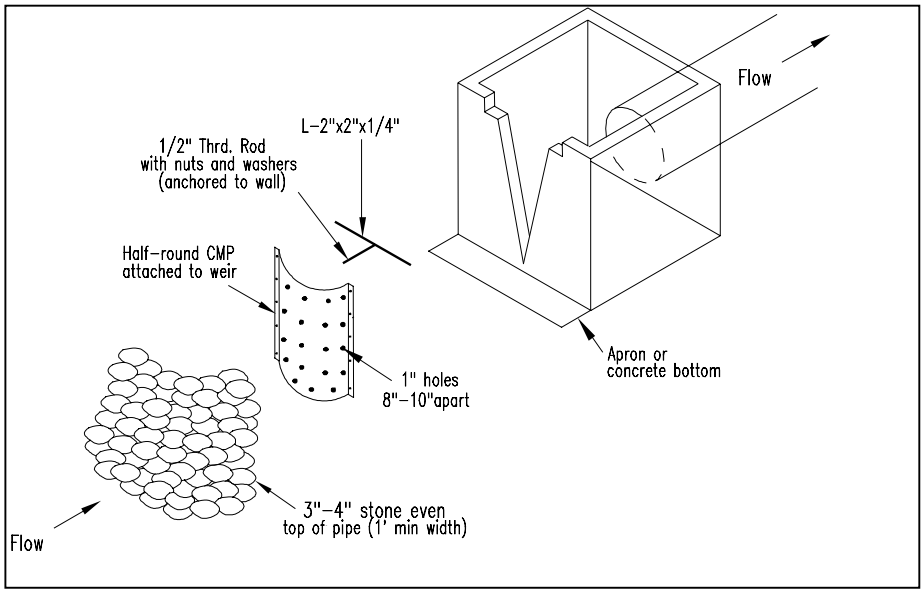


Figure 4.8.2 Perforated Half-Round Pipe Retrofit with Stone Filter Installation Requirements

2. Slotted Board Dam With Stone (See Figure 4.8.3)

   a. Can be used with open end pipe outlets, winged headwalls, or concrete weir outlets.

   b. Should be installed with minimum size 4-foot by 4-foot posts.

   c. Boards shall have 0.5- to 1-inch space between them.

   d. Minimum size 3- to 5-inch stone filter shall be installed around the upstream side of the board dam.

   e. Can be used in detention ponds with drainage areas up to 50 acres.

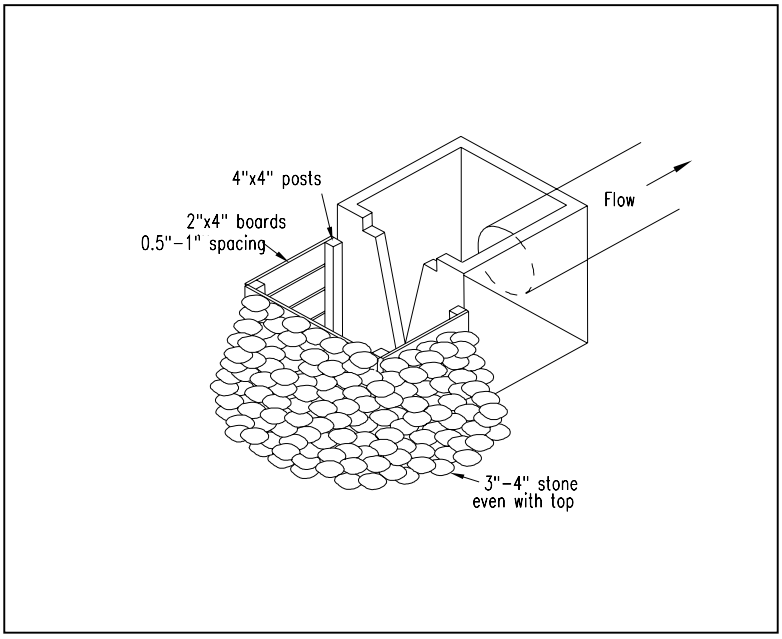


Figure 4.8.3 Slotted Board Dam Installation

Requirements

3. Stone Filter Rings

    a. Can be used in conjunction with half-rounds or board dams, as additional sediment filtering device.

    b. For pipe diameters larger than 12 inches, stone size should be a minimum 10- to 15-inch stone, faced with smaller filter stone on the upstream side, if necessary.

4. All disturbed areas shall be vegetated immediately after construction with perennial vegetation.

Maintenance

All types of retrofit structures must be kept clear of trash and debris. This will require continuous monitoring and maintenance, which includes sediment removal when one-third full. Structures are temporary and should be removed when the land-disturbing project has been restabilized.

4.9 Sediment Barrier

Sd1

Definition

Sediment barriers are temporary structures typically constructed of silt fence supported by steel or wood posts. Other types of barriers may include sandbags, straw bales, brush piles, and other filtering material.

Purpose

Sediment barrier are used to prevent sediment carried by sheet flow from leaving the site and entering natural drainage ways or storm drainage systems by slowing stormwater runoff and causing the deposition of sediment at the structure.

Conditions

Use sediment barriers under the following conditions:

1. Below small disturbed areas less than ¼ acre per 100 feet of fence.

2. Where runoff can be stored behind the sediment fence without damaging the fence or the submerged area behind the fence.

Do not install sediment fences across streams, ditches, or waterways.

Design Criteria

Ensure that the drainage area is no greater than ¼ acre per 100 feet of non-reinforced fence. For wire-reinforced fence, the drainage area should not exceed ½ acre.

Make the fence stable for the runoff from 10-year, 24-hour storm or the storm specified by local code. Where all runoff is to be stored behind the fence, ensure that the maximum slope length behind the sediment fence does not exceed the specifications shown in Table 4.9.1.

If non-erosive outlets are provided, slope length may be increased beyond that shown in Table 4.9.1, but runoff from the area should be determined, and bypass capacity and erosion potential along the fence must be checked. The velocity of the flow at the outlet

or along the fence should be consistent with velocities and flow limitations shown on Table 4.9.1.

TABLE 4.9.1

Criteria for Sediment Barrier Placement

Land Slope (percent)	Maximum Slope Length Behind Fence (feet)
<2	100
2 to 5	75
5 to 10	50
10 to 20	25
> 20	15

Provide a riprap splash pad or other outlet protection device for any point such as natural depressions or swales where flow may top the sediment fence. Ensure that the maximum height of the fence at a protected, reinforced outlet does not exceed 1 foot and that support post spacing does not exceed 4 feet.

The design life of a synthetic sediment fence should be 6 months. Burlap is only acceptable for periods up to 60 days.

Construction Specifications

Sandbags

Sandbags should be installed so that flow under or between bags is minimal. Anchoring with steel rods may be required if structure height exceeds two bags. Use of sandbags must be approved by the local issuing authority.

Hay or Straw Bales

Bales will be placed lengthwise in a single row, on the contour, and embedded in the soil to a depth of 4 inches. Bales must be securely anchored in place by stakes or bars driven through the bales or by other acceptable means to prevent displacement. Figure 4.9.1 indicates installation requirements for straw bale barriers.

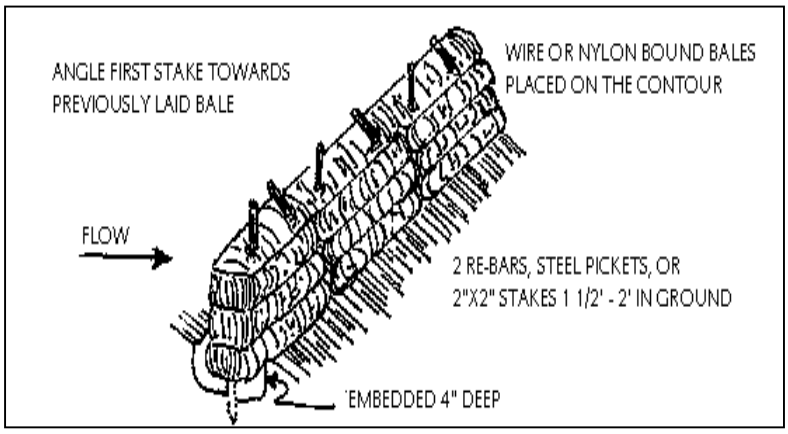


Figure 4.9.1 Straw Bale Barrier Installation Requirements

Brush

Brush obtained from clearing operations may be piled in a row along the perimeter of land-disturbing activities. Brush should be windrowed on the contour as nearly as possible.

Brush may require compaction. Construction equipment may be used to accomplish this purpose.

If greater filtering capacity is required, a commercially available filtering fabric may be placed on the construction side of the brush barrier. The lower edge of the fabric must be buried in a trench 4 to 6 inches deep. The upper edge must be stapled, tied, or otherwise fastened to the brush barrier.

Brush barriers should be removed after the area is stabilized if the barrier is not aesthetically acceptable.

Silt Fence

A silt fence is specifically designed to allow water to pass through while retaining sediment on-site. A silt fence may be used in conjunction with a straw bale barrier to improve effectiveness and provide additional stability.

Silt Fence Specifications

Two widths of silt fence are available, Type A or C (36 inches high) and Type B (22 inches high). In order to determine the most suitable type fence, project duration, slope

gradient, and slope length must be considered (see Table 4.9.2). A silt fence must meet the minimum standards set forth.

TABLE 4.9.2

Silt Fence Types

Width of Fabric	Use
Type A (36 inches)	On developments where the life of the project is greater than or equal to 6 months.
	Where the slope gradient is steeper than 3:1.
Type B (22 inches)	On projects such as residential home sites or small commercial developments, where the life of the project is less than 6 months.
	Where the slope gradient is less than or equal to 3:1.
Type C (36 inches)	Where fill slopes exceed a vertical height of 20 feet and the slope gradient is steeper than 3:1.

Silt Fence Installation

The contractor must install the temporary silt fence according to this specification, as shown on the plans, or as directed by the engineer. For installation of Type A, B, or C, see Figures 4.9.2, 4.9.3, and 4.9.4, respectively.

Post installation must start at the center of the low point (if applicable) with remaining posts spaced at 6-foot intervals. For post size requirements of Type A or C and B fabric, see Table 4.9.3. Fasteners for wood posts are listed in Table 4.9.4.

TABLE 4.9.3

Post Sizes

Fabric	Minimum Length	Type of Post	Size of Post
Type A	4 feet	Soft wood	3-Inch-Diameter of 2 by 4 Inches
		Oak	
		Steel	1.5-Inch by 1.5-Inch-Diameter
			1.3-Pound per Foot Minimum
Type B	3 feet	Soft wood	2-Inch-Diameter or 2 by 2 Inches
		Oak	
		Steel	1-Inch by 1-Inch

			.75-Pound per Foot Minimum
Type C	4 feet	Steel	1.3-Pound per Foot Minimum

TABLE 4.9.4

Fasteners for Wood Posts

Fastener	Gauge	Crown/Length	Legs/ Button Heads	Staples/Nails per Post
Wire Staples	17 min.	¾ inch wide	½ inch long	5 min.
Nails	14 min.	1 inch	¾ inch	4 min.

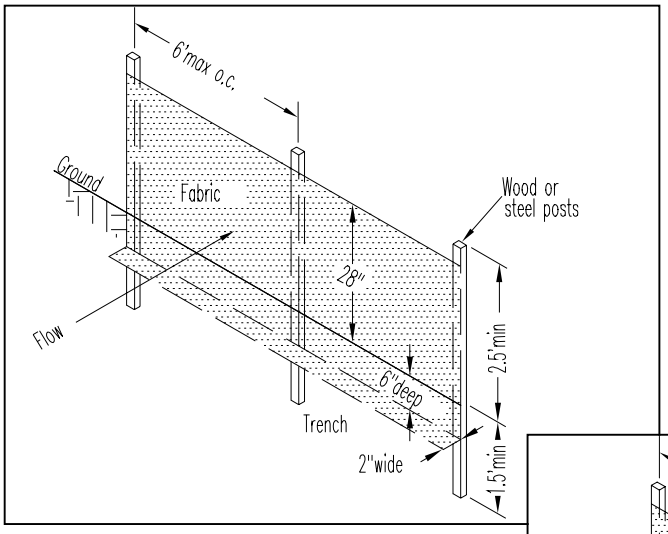


Figure 4.9.2 Use Type “A” Silt Fence

Silt Fence Maintenance and Removal

The contractor must maintain the silt fence until the project is vegetated or accepted. Filter fabric must be replaced when it has deteriorated to such an extent that the effectiveness of the fabric is reduced.

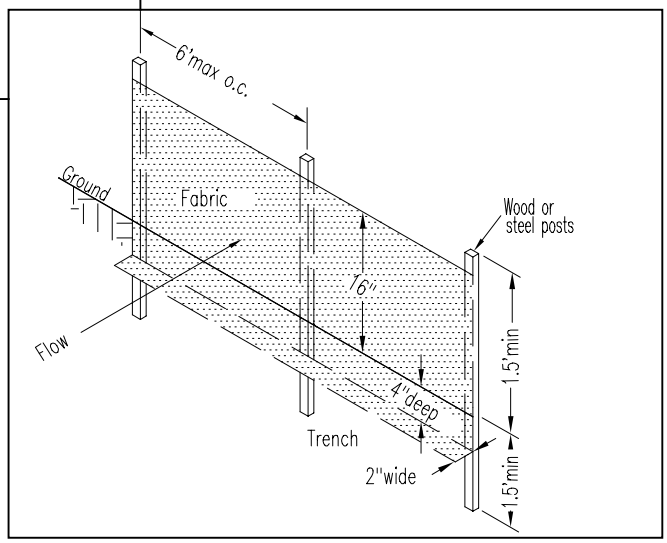


Figure 4.9.3 Use Type “B” Silt Fence

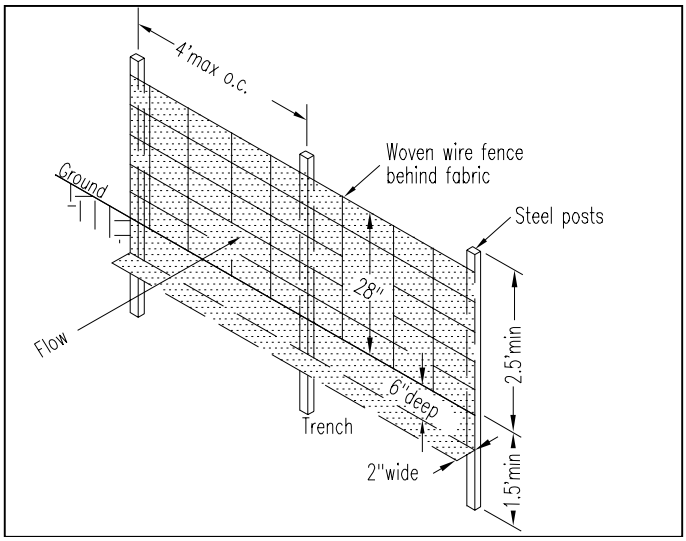


Figure 4.9.4 Type “C” Silt Fence

Figure 4.9.5 Typical Type “C” Silt

TABLE 4.9.5

Silt Fencing Specifications

Type Fence	A	B	C
Tensile Strength (lbs. Min)[1] (ASTM D-4632)	Warp – 120	Warp – 120	Warp – 260
	Fill – 100	Fill – 100	Fill – 180
Elongation (% Max) (ASTM D-4632)	40	40	40
Apparent Opening Size (Max. Sieve Size) (ASTM D-4751)	#30	#30	#30
Flow Rate (Gal/Min/Sq. Ft) (GDT-87)	25	25	70
Ultraviolet Stability[2] (ASTM D-4632 after 300 hours weathering in accordance with ASTM D-4355)	80	80	80
Bursting Strength (PSI Min.) (ASTM D-3786 Diaphragm Bursting Strength Tester)	175	175	175
Minimum Fabric Width (inches)	36	22	36

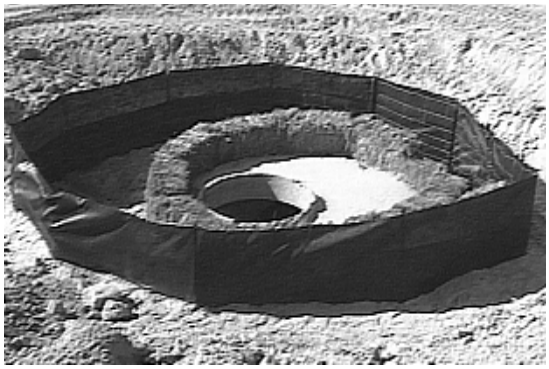
[1] Minimum roll average of five specimens.
[2] Percent of required initial minimum tensile strength.

4.10 Inlet Sediment Trap

Sd2

Definition

A temporary protective device formed around or installed in a storm drain drop inlet to trap sediment.



Purpose

An inlet sediment trap is used to prevent sediment from leaving the site or from entering storm drainage systems, prior to permanent stabilization of the disturbed area.

Conditions

Sediment traps should be installed in or around all storm drain drop inlets that receive runoff from disturbed areas. Outlet protection should be installed below storm drain outlets to prevent scouring.

Design Criteria

Many sediment filtering devices can be designed to serve as temporary sediment traps. Examples are shown in the following figures. Where excavation is to be used, it shall be one in combination with a sediment filter such as stone or silt fence. All excavated sediment traps should provide a minimum of 1.5 feet of sediment storage. Sediment traps must be self-draining unless they are otherwise protected in an approved fashion that will not present a safety hazard.

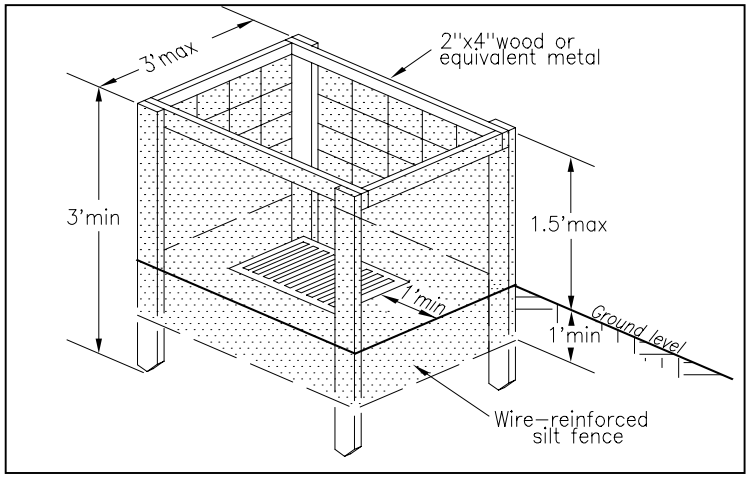


Figure 4.10.1 Fabric and Supporting Frame for Inlet protection.

For block and gravel drop inlet protection as shown in Figure 4.10.2, lay one block on each side of the structure on its side in the bottom row to allow pool drainage. The foundation should be excavated at least 2 inches below the crest of the storm drain. Place the bottom row of blocks against the edge of the storm drain for lateral support and to avoid washouts when overflow occurs. If needed, give lateral support to subsequent rows by placing 2-inch by 4-foot wood studs through block opening. Carefully fit hardware cloth or comparable wire mesh with ½-inch openings over all block openings to hold gravel in place. Use clean gravel placed 2 inches below the top of the block on a 2:1 slope or flatter and smooth it to an even grade. The DOT No. 57 washed stone is recommended.

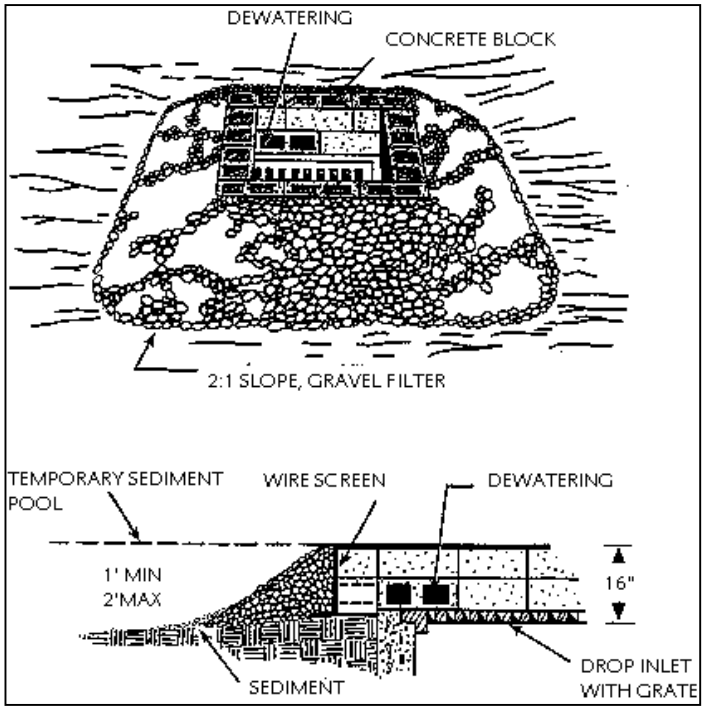


Figure 14.10.2 Block and Gravel Drop Inlet Protection Installation Requirements

For gravel drop inlet protection as shown in Figure 4.10.2, stone and gravel are used. Keep the slope toward the inlet no steeper than 3:1. Leave a minimum 1-foot-wide level stone area between the structure and around the inlet to prevent gravel from entering the inlet. On the slope toward the inlet, use stones 3 inches in diameter and larger. On the slope away from the inlet, use ½- to ¾-inch gravel (No. 57 washed stone) at a minimum thickness of 1 foot.

Construction Specifications

Sediment traps may be constructed on natural ground surface, on an excavated surface, or on machine-compacted fill provided they have a non-erodible outlet. Manufactured traps are also available for installation in drain inlet structures or as stand-alone tanks.

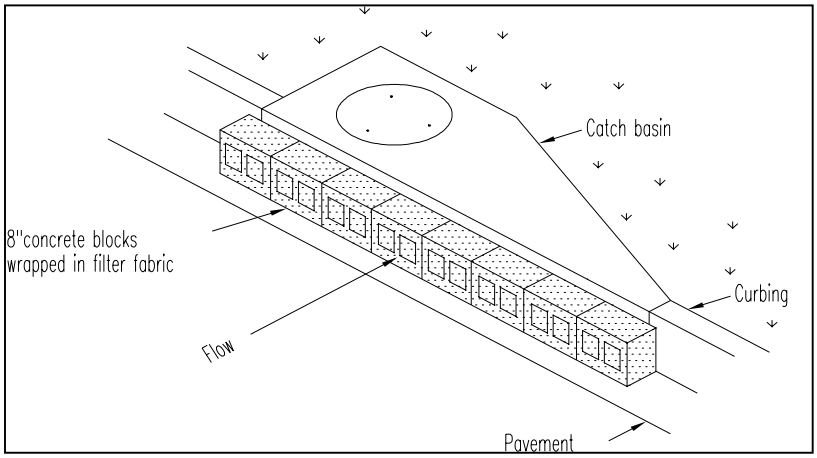


Figure 4.10.3 Curb Inlet Filter Installation Requirements

Maintenance

Inspect the trap after each rainfall and make repairs as needed. The traps must also be checked at the end of each working day and repaired or cleaned as necessary to ensure proper function.

Remove sediment as necessary to provide adequate storage volume for subsequent rains. When the contributing drainage area has been adequately stabilized, remove all materials and any unstable soil and either salvage it or dispose of it properly. Bring the disturbed area to proper grade, then smooth and compact it. Appropriately stabilize all bare areas around the inlet.

4.11 Portable Sediment Tank

Definition

A sediment tank is a compartmental tank container through which sediment-laden water is pumped to trap and retain the sediment.

Purpose

A sediment tanks is used to trap and retain sediment prior to pumping the water to drainageways, adjoining properties, and rights-of-way below the sediment tank site.

Conditions Where Practice Applies

A sediment tank is to be used on sites where excavations are deep and space is limited, such as urban construction, where direct discharge or sediment-laden water to stream sand storm drainage systems is to be avoided.

Design Criteria

Location

The sediment tank shall be located for ease of clean out and disposal of the trapped sediment and to minimize the interference with construction activities and pedestrian traffic.

Tank Size

The following formula should be used in determining the storage volume of the sediment tank:

Pump Discharge (GPM) x 16 = Cubic Foot Storage

A variety of manufactured sediment tanks is available. Various designs can be used if the storage volume is adequate and approval is obtained from the local approving agency.

Internal Sediment Traps

The following manufactured sediment trap for stormwater inlets has been approved as a BMP for construction activity and is particularly suited for urban and paved environments where conventional inlet protection practices may be ineffective.

The manufacturer’s product and specifications are provided as an example of this type of device and are not intended to exclude equivalent or similar products. Use of

alternative products or devices requires the prior approval of the local controlling jurisdictions.

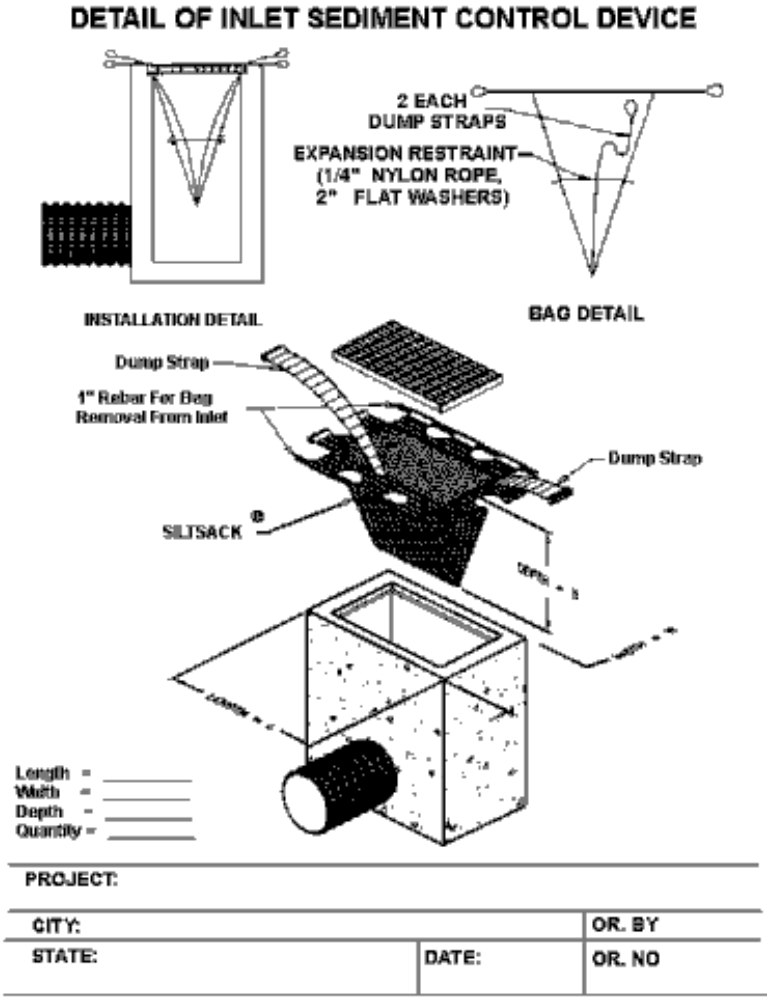


Figure 4.11.1 “Silksack” manufactured by ACF Environmental, 1901-A Willis Road, Richmond, VA 23237 Phone 800/644-9223

4.12 Temporary Sediment Basin

Sd3

Definition

A basin created by constructing a barrier or dam across a waterway or by excavating a basin or by a combination of both. A basin typically consists of a dam, a pipe outlet, and an emergency spillway. The size of the structure will depend upon the location, size of drainage area, soil type, and rainfall pattern.

Purpose

Sediment basins are used to detain runoff waters and trap sediment from erodible areas in order to protect properties and drainage ways below the installation from damage by excessive sedimentation and debris. The water is temporarily stored and the bulk of the sediment carried by the water is filtered and retained in the basin while the water is automatically released.

Conditions

This practice applies to critical areas where physical site conditions, construction schedules, or other restrictions preclude the installation or establishment of other erosion control practices to satisfactorily reduce runoff, erosion, and sedimentation. The structure may be used in combination with other practices and should remain in effect until the sediment-producing area is permanently stabilized.

This standard applies to the installation of temporary (to be removed within 12 months) sediment basins on sites where: (1) failure of the structure would not result in loss of life or interruption of use or service of public utilities, and (2) the drainage area does not exceed 50 acres.

Design Criteria for Temporary Sediment Basins

Compliance with Laws and Regulations

Design and construction must comply with state and local laws, ordinances, rules, and regulations and must be prepared by a registered professional engineer. The following information is provided for reference and to establish minimum norms. Temporary

sediment basins may be considered small dams and be subject to state regulations governing design and construction.

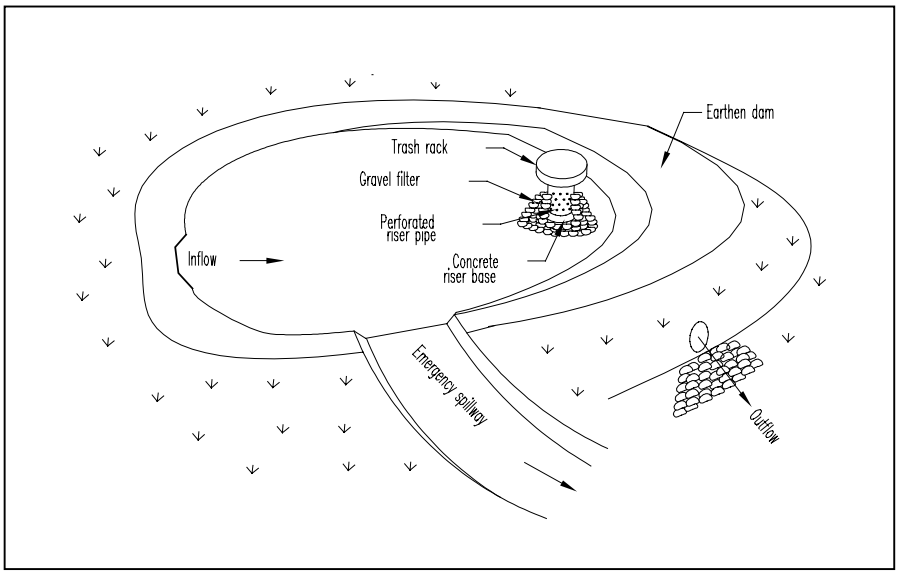


Figure 4.12.1 Components of a Typical Temporary Sediment Basin

Location

The sediment basin should be located to obtain the maximum storage benefit from the terrain and for ease of cleanout of the trapped sediment. It should also be located to minimize interference with construction activities and construction of utilities.

Sediment basins should be located so that storm drains discharge into the basin. They should never be placed in live streams.

Volume of the Basin

Ensure that the sediment storage volume of the basin, as measured to the elevation of the crest of the principal spillway, is at least 67 cubic yards per acre for the disturbed area draining into the basin (67 cubic yards is equivalent to ½ inch of sediment per acre of basin drainage area). Where possible, the entire drainage basin is used for this computation, rather than the disturbed area alone, to help ensure adequate trapping efficiency. Remove sediment from the basin when approximately one-third of the storage volume has been filled. This volume shall be marked on the riser or by setting a marked post near the riser.

Surface Area

The following relationship between surface area and peak inflow rate is to be maintained as a minimum to achieve adequate trapping efficiency. Certain soil types such as silty clays may require greater surface areas and longer travel times within the basin to be effective. Ultimately, the adequacy is measured against the quality of the discharge.

$$A = 0.01q$$

where A is basin surface area in acres and q is peak inflow rate in cfs. Area is measured at the crest of the principal spillway riser. The minimum peak inflow rate is determined from a 2-year, 24-hour storm.

Shape of the Basin

It is recommended that the design of a sediment basin incorporate features to maximize travel time of flow within the basin. Suggested methods of accomplishing this objective include:

1. Length to width ratio greater than 2:1, where length is the distance between the inlet and outlet.

2. A wedge shape with the inlet located at the narrow end.

3. Use of baffles and diversions to increase the flow length.

The dimensions necessary to obtain the required basin volume and surface area shall be clearly shown on the plans to facilitate plan review, construction, and inspection.

Spillways

Runoff computations shall be based upon the worst soil-cover conditions expected to prevail in the contributing drainage area during the anticipated effective life of the structure. The combined capacities of the principal and emergency spillway shall be sufficient to pass the peak rate of runoff for a 25-year, 24-hour frequency storm.

1. **Principal Spillway –** A spillway consisting of a vertical pipe or box-type riser joined (watertight connection) to a pipe, which shall extend through the embankment and outlet beyond the downstream toe of the fill shall be provided. The metal gauge thickness shall comply with DOT specifications. The discharge shall be based on a 2-year, 24-hour storm for the total drainage area without causing flow through the emergency spillway. The appropriate disturbed soil cover

condition shall be used. The minimum size of the pipe shall be 8 inches in diameter. Principal spillway capacities must be determined from calculations and provided. Weir flow discharge above the crest of the riser must be determined and calculations provided.

a. Crest Elevation – The crest elevation of the riser shall be a minimum of 1 foot below the elevation of the control section of the emergency spillway.

b. Watertight Barrel Assembly – The riser and all pipe connections shall be completely watertight except for the inlet opening at the top or dewatering openings, and shall not have any other holes, leaks, rips, or perforations.

c. Dewatering the Basin – Retention time within the basin is an important factor in effective sedimentation retention. Perforate the lower half of the riser with ½-inch holes spaced approximately 3 inches apart. Cover with 2 feet of ½- to ¾-inch aggregate, No. 57, or No. 5 clean stone.

d. Trash Rack and Anti-Vortex Device – A trash rack and anti-vortex device shall be securely installed on top of the riser and may be the type as shown in Figure 4.12.2.

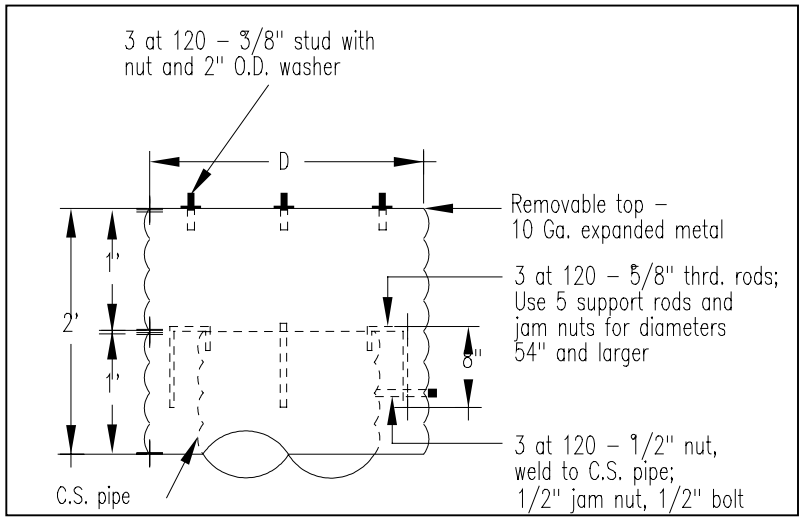


Figure 4.12.2 Typical Sediment Basin Trash Rack

e. Base – The riser shall have a base attached with a watertight connection and shall have sufficient weight to prevent flotation of the riser. An 18-inch-thick concrete base with the riser embedded 9 inches in the base is recommended.

Computations shall be made to design a base that will prevent flotation. The minimum factor of safety shall be 1.20 (downward forces – 1.20 x upward forces).

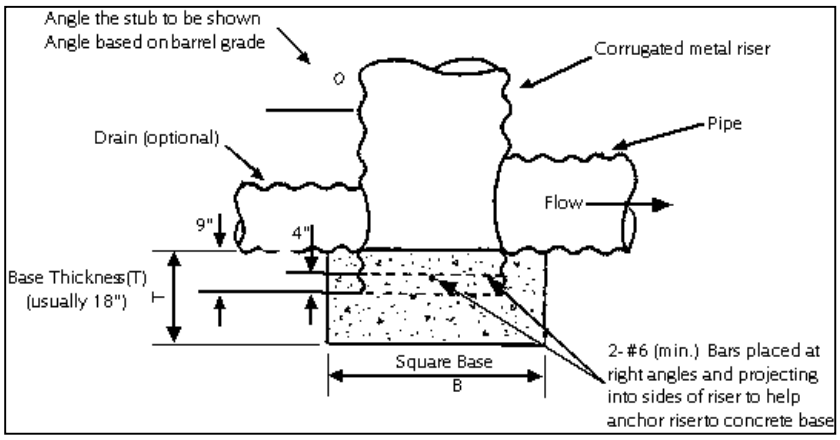


Figure 4.12.3 Concrete Riser Base Detail

f. Anti-Seep Collars – One anti-seep collar shall be installed around the pipe, near the center of the dam, when any of the following conditions exist:

- The settled height of the dam is greater than 12 feet.
- The conduit is smooth pipe larger than 8 inches in diameter.
- The conduit is corrugated metal pipe larger than 12 inches in diameter.

Use an anti-seep collar with an 18-inch projection for heads (H) less than or equal to 10 feet and a 24-inch projection for heads (H) greater than 10 feet. The anti-seep collar and its connection shall be watertight.

g. Outlet – An outlet shall be provided, including a means of conveying the discharge in an erosion-free manner to an existing stable channel. Where discharge occurs at the property line, drainage easements will be obtained in accordance with local ordinances. Adequate notes and references will be shown on the erosion and sediment control plan. Protection against scour at the discharge end of the pipe spillway shall be provided. Measures may include excavated plunge pools, riprap, impact basins, revetments, or other approved methods.

h. For typical features of a temporary sediment basin, see Figure 4.12.4.

2. **Emergency Spillway –** The entire flow area of the emergency spillway shall be constructed in undisturbed ground (not fill). The emergency spillway shall be designed by a registered professional engineer.

   a. Capacity – The minimum capacity of the emergency spillway shall be that required to pass the peak rate of runoff form the 25-year, 24-hour frequency storm, less any reduction due to flow in the principal spillway. The appropriate disturbed soil cover condition shall be used.

   b. Velocities – The velocity of flow in the exit channel shall not exceed 5 feet per second for vegetated channels. For channels with erosion protection other than vegetation, velocities shall be within the non-erosive range for the type of protection used.

   c. Erosion Protection – Vegetation, riprap, asphalt, or concrete shall be provided to prevent erosion.

   d. Freeboard – Freeboard is the difference between the design high water elevation in the emergency spillway and the top of the settled embankment. The freeboard shall be at least 1 foot.

Entrance of Runoff into Basin

Points of entrance of surface runoff into excavated sediment basins shall be protected to prevent erosion and sediment generation. Dikes, swales, or other water control devices shall be installed as necessary to direct runoff into the basin. Points of runoff entry should be located as far from the riser as possible to maximize travel time.

Construction Specifications

Site Preparation

Areas under the embankment and under structural works shall be cleared, grubbed, and stripped of topsoil. All trees, vegetation, roots, and other objectionable material shall be removed and disposed of by approved methods. To facilitate cleanout or restoration, the pool area (measured at the top of the pipe spillway) will be cleared of all brush and trees.

Cut-Off Trench

A cut-off trench will be excavated along the centerline of earth fill embankments. The minimum depth shall be 2 feet. The cut-off trench shall extend up both abutments to the riser crest elevation. The minimum bottom width shall be 4 feet and must be of adequate width to allow operation of compaction equipment. The side slopes shall be no steeper than 1:1. Compaction requirements shall be the same as those for the embankment. The trench shall be drained during the backfilling and compaction operations.

Embankment

Fill material shall be taken from approved areas shown on the plans. It shall be clean mineral soil free of roots, woody vegetation, oversized stones, rocks, or other objectionable materials. Relatively pervious materials such as sand or gravel shall be placed in the downstream section of the embankment. Areas where fill is to be placed shall be scarified prior to fill placement. The fill material shall contain sufficient moisture so it can be formed by hand into a ball without crumbling. If water can be squeezed from the ball, the fill is too wet for proper compaction. Fill material shall be placed in 6- to 8-inch-thick continuous layers over the entire length of the fill. Compaction shall be obtained by routing and hauling the construction equipment over the fill so that the entire surface of the fill is traversed by at least one wheel or tread track of the equipment or by use of a compactor. The embankment shall be constructed to an elevation 5 percent higher than the design height to allow for settlement.

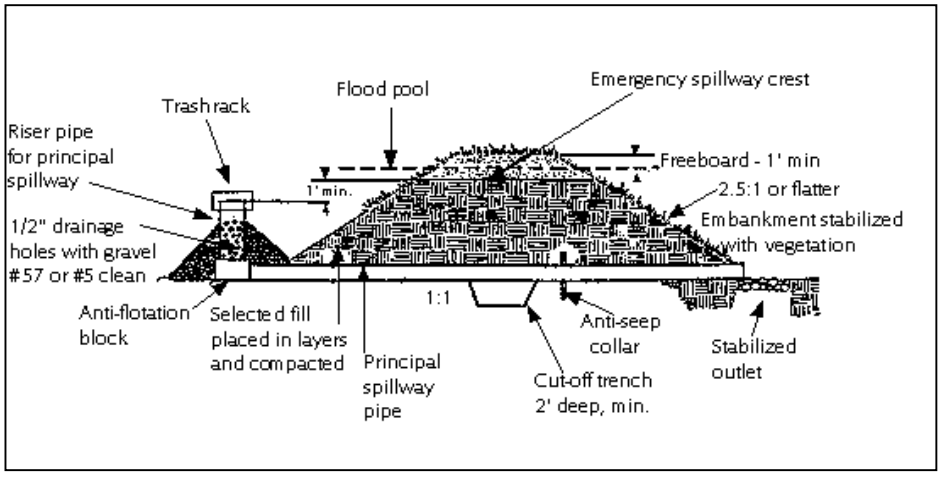


Figure 4.12.4 Section Through Embankment and Typical Features

Principal Spillway

The riser shall be securely attached to the pipe or pipe stub by welding the full circumference, making a watertight structural connection. The pipe stub must be attached to the riser at the same percent (angle) of grade as the outlet conduit. The connection between the riser and the riser base shall be achieved by approved watertight bank assemblies. The pipe and riser shall be placed on a firm, smooth foundation of impervious soil as the embankment is constructed. Breaching the embankment is unacceptable. Pervious materials such as sand, gravel, or crushed stone shall not be used as backfill around the pipe or anti-seep collar. The fill material around the pipe spillway shall be placed in 4-inch layers and compacted under and around the pipe to at least the same density as the adjacent embankment. Care must be taken not to raise the pipe from firm contact with its foundation when compacting under the pipe haunches. A minimum depth of 2 feet of hand-compacted backfill shall be placed over the pipe spillway before crossing the spillway with construction equipment.

Emergency Spillway

The emergency spillway shall be installed in undisturbed ground. Planned elevations, grades, design width, and entrance and exit channel slopes are critical to the successful operation of the emergency spillway and must be constructed within a tolerance of 0.1 foot.

Vegetative Treatment

Stabilize the embankment and all other disturbed areas in accordance with the appropriate permanent vegetative measure, Ds3, immediately following construction. In no case shall the embankment remain unstabilized for more than 7 days.

Erosion and Pollution Control

Construction operations will be executed in a manner that erosion and water pollution will be minimized. Compliance with state and local law concerning pollution abatement shall be maintained.

Safety

State and local requirements shall be met concerning fencing and signs to warn the public of hazards of soft sediment and floodwater.

Maintenance

All damages caused by soil erosion or construction equipment must be repaired at the end of each working day. Sediment shall be removed from the basin when it reaches

the specified distance below the top of the riser. Removed sediment shall be placed and stabilized in such a manner that it will not erode from the site. The sediment shall not be deposited downstream from the embankment or adjacent to a stream or floodplain.

Final Disposal

When temporary structures have served the intended purpose and the contributing drainage area has been properly stabilized, the embankment and resulting sediment deposits are to be leveled or otherwise disposed of in accordance with an approved sediment control plan. The proposed use of a sediment basin site will often dictate final disposition of the basin and any sediment contained therein. If the site is scheduled for future construction, the embankment and trapped sediment must be removed, safely disposed of, and backfilled with a structural fill. When the basin area is to remain open space, the pond may be pumped dry, graded, and backfilled.

Submittal Information

Sediment basin designs and construction plans submitted for review shall include the following:

1. Specific location of the basin.

2. Plan view of the storage basin and emergency spillway showing existing and proposed contours.

3. Cross-section of dam, principal spillway, and emergency spillway, and profile of emergency spillway.

4. Details of pipe connections, riser to pipe connections, riser base, anti-seep collars, trash rack, cleanout elevation, and anti-vortex device.

5. Runoff calculations for the 2-year frequency principal spillway storm and the disturbed condition 25-year frequency emergency spillway storm.

6. Storage computations

    a. Total required

    b. Total available

c. Level of sediment at which cleanout shall be required shall be stated as distance from the riser crest to the sediment surface.

7. Calculations showing design of pipe and emergency spillway.

8. Maintenance equipment access points.

9. The seal of a registered professional engineer.

Temporary Sediment Basin Design Data Sheet

The following information, specification, and calculation data is to be supplied with the Erosion and Pollution Control Plan for a temporary sediment design submittal:

1. The minimum required volume of storage is 67 cubic yards per acre for each acre of disturbed drainage area, although when possible, the total drainage area should be used. Volume should be computed form contour information. A stage-storage curve should be developed for the site showing elevation versus accumulated volume. The contour map is used to measure areas for various contour intervals from the basin bottom to the expected top of dam elevation. The storage volume within the basin is usually natural storage and storage gained from excavated soil that will be used for construction of the dam.

2. The volume of the basin for cleanout of sediment is 22 cubic yards per acre for each acre of drainage area. As the basin fills with sediment to this volume, the sediment shall be removed to restore the original design volume.

3. Determine the design elevation for the minimum required storage volume of the basin. The design elevation is set at the principal spillway riser crest to provide the required 67 cubic yards per acre of drainage area.

4. Determine the design elevation of the sediment cleanout pool level. The basin shall be dewatered to this elevation using perforations in the riser pipe. This design elevation corresponds to the 22 cubic yards per acre.

5. Determine the distance of basin cleanout below the riser crest. The cleanout elevation shall be clearly marked on the riser or by use of a marked post near the riser.

6. Compute the peak discharge rates (for the 2-year and 25-year, 24-hour storm events) for the principal and emergency spillways using accepted engineering practices. The worst disturbed land-use condition shall be used.

7. Determine the value of "H", the vertical distance between the centerline of the outlet pipe and the emergency spillway crest. Determine the pipe length.

8. Determine the pipe diameter and Q_{PS} to pass the 2-year peak discharge (Q_2).

9. Determine the riser diameter and elevation and provide a minimum of 1-foot freeboard to the emergency spillway elevation.

10. Determine the trash rack anti-vortex device size.

11. Compute the emergency spillway capacity (Q_{ES}) by subtracting the actual flow carried by the principal spillway from Q_{25}.

12. Determine the emergency spillway entrance channel slope, exit channels slope, bottom width, and flow stage values.

13. Specify an anti-seep collar, if required.

14. Determine the design elevations of the riser crest, emergency spillway, design high water, and the top of the dam.

15. Determine the minimum surface area required.

4.13 Temporary Stream Crossings

Sr

Definition

A temporary structure installed across a flowing stream or water course for use by construction equipment.

Purpose

Temporary stream crossings are used to protect streams from damage and erosion.

Conditions

Temporary stream crossing may include bridges, round pipes, or pipe arches. This standard does not apply to streams with drainage areas greater than 1 square mile. Very small streams may be crossed using protected fords such as rock riprap. Installation may be subject to state regulations.

Design Criteria

Figure 4.13.1 shows installation requirements for temporary stream crossings.

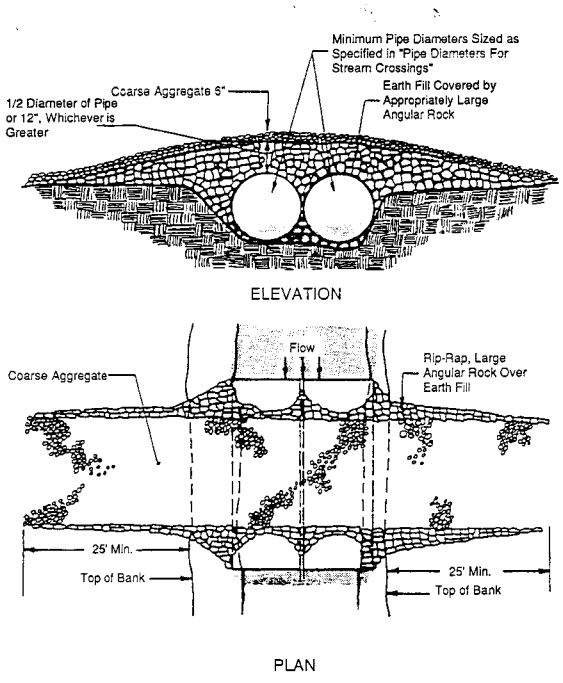


Figure 4.13.1 Temporary Stream Crossing Installation

Size

The structure shall be large enough to convey the full bank flow of the stream without appreciably altering the stream flow characteristic. Pipe openings may be obtained from Table 4.13.1.

TABLE 4.13.1

Pipe Diameters for Stream Crossings*

Drainage Area (acres)	Average Slope of Watershed			
	1%	4%	8%	16%
1-25	24	24	30	30
26-50	24	30	36	36
51-100	30	36	42	48
101-150	30	42	48	48
151-200	36	42	48	54
201-250	36	48	54	54
251-300	36	48	54	60
301-350	42	48	60	60
351-400	42	54	60	60
401-450	42	54	60	72
451-500	42	54	60	72
501-550	48	60	60	72
551-600	48	60	60	72
601-640	48	60	72	72

*Assumptions for determining the table: USDA-NRCS Peak Discharge Method CN = 65; rainfall depth = 3.7 inches for 2-year frequency. Pipe diameters shown in the table are in inches.

Overflow Protection

Structures shall be protected from washout during periods of peak discharges by diverting water around the structures. Methods to be considered for washout protection may include elevation of bridges above adjacent flood plain lands, crowning of fills over pipes, or by the use of diversions, dikes, or island type structures. Structures shall be designed to withstand flows from a 10-year, 24-hour frequency storm or the storm specified by governing code or ordinance.

Construction Specifications

1. Clearing and excavation of the streambed and banks shall be kept to a minimum.

2. The structure shall be removed as soon as it is no longer necessary for project construction.

3. Upon removal of the structure, the stream shall immediately be reshaped to its original cross section and properly stabilized.

Maintenance

The structure shall be inspected after every rainfall and at least once a week, whether it has rained or not, and all damages repaired immediately.

4.14 Storm Drain Outlet Protection

St

Definition

Paved and/or riprapped channel sections placed below storm drain outlets.

Purpose

Channel sections are used to reduce velocity of flow before entering receiving channels below storm drain outlets.

Conditions

This standard applies to all storm drain outlets, road culverts, paved channel outlets, etc., discharging into natural or constructed channels. Analysis and/or treatment will extend from the end of the conduit, channel, or structure to the point of entry into an existing stream or publicly maintained drainage system. Professional engineering assistance is recommended.

Design Criteria

Structurally lined aprons at the outlets of pipes and paved channel sections shall be designed according to the following criteria:

Capacity

Peak storm flow from the 10-year, 24-hour frequency storm or the storm specified code or the design discharge of the water conveyance structure, whichever is greater.

Tailwater Depth

The depth of tailwater immediately below the pipe outlet must be determined for the design capacity of the pipe. Manning's equation may be used to determine tailwater depth. If the tailwater depth is less than half the diameter of the outlet pipe, it shall be classified as a minimum tailwater condition. If the tailwater depth is greater than half the pipe diameter, it shall be classified as a maximum tailwater condition. Pipes that outlet onto flat areas with no defined channel may be assumed to have a minimum tailwater condition.

Apron Length and Thickness

The apron length and d_{50}, stone median size, shall be determined from accepted empirical tailwater conditions, stone size, pipe size, and discharge rate. A maximum stone size at 1.5 x d_{50} may be assumed and an apron thickness of 1.5 x d_{max} may be used.

Calculations, curve data, and source are to be provided.

Apron Width

If the pipe discharges directly into a well-defined channel, the apron shall extend across the channel bottom and up the channel banks to an elevation 1 foot above the maximum tailwater depth or to the top of the bank, whichever is less. If the pipe discharges onto a flat area with no defined channel, the width of the apron shall be determined as follows:

1. The upstream end of the apron, adjacent to the pipe, shall have a width three times the diameter of the outlet pipe.

2. For a Minimum Tailwater Condition, the downstream end of the apron shall have a width equal to three pipe diameters plus the length of the apron.

3. For a Maximum Tailwater Condition, the downstream end shall have a width equal to three pipe diameters plus 0.4 times the length of the apron.

Bottom Grade

The apron shall be constructed with no slope along its length (0.0% grade). The invert elevation of the downstream end of the apron shall be equal to the elevation of the invert of the receiving channel. There shall be no overfall at the end of the apron.

Side Slope

If the pipe discharges into a well-defined channel, the side slopes of the channel shall not be steeper than 2:1 (horizontal:vertical).

Alignment

The apron shall be located so that there are no bends in the horizontal alignment.

Materials

The apron may be lined with riprap, grouted riprap, or concrete. The gradation, quality, and placement of riprap shall conform to applicable construction specifications.

Alternative structures for achieving energy dissipation at an outlet may be submitted for approval.

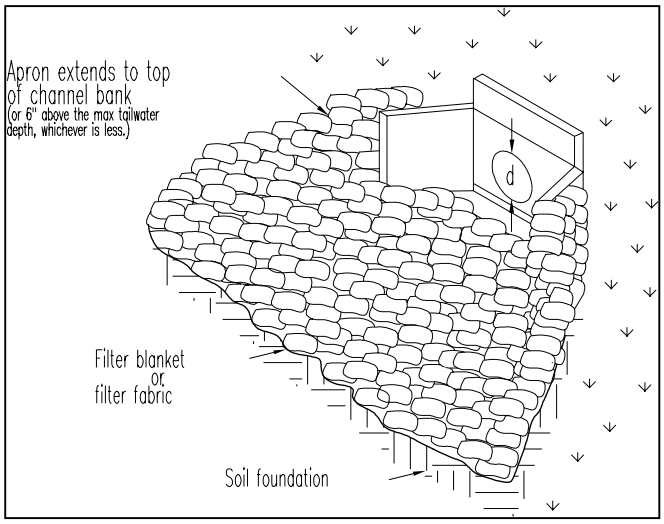


Figure 17.1 Outlet Protection for a Well-Defined Channel

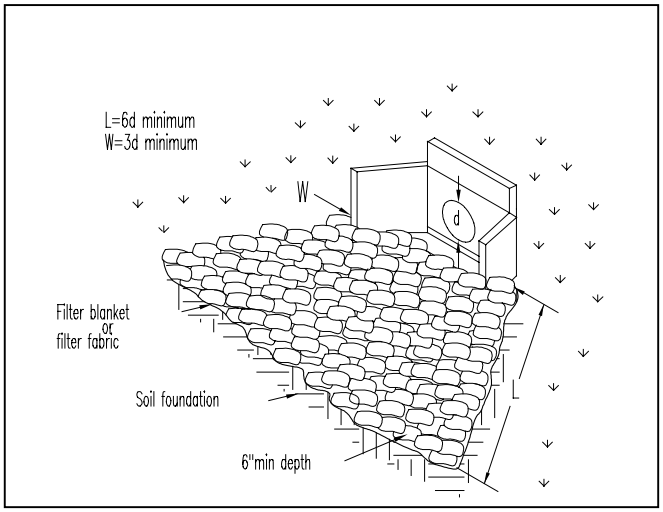


Figure 17.2 Outlet Protection for a Flat Area

Construction Specifications

1. Ensure that the subgrade for the filter and riprap follows the required lines and grades shown in the plan. Compact any fill required in the subgrade to the density of the surrounding undisturbed material. Low areas in the subgrade on undisturbed soil may also be filled by increasing the riprap thickness.

2. The riprap and gravel filter must conform to the specified grading limits shown on the plans.

3. When used, filter fabric must meet design requirements and be properly protected from puncturing or tearing during installation. Repair any damage by removing the riprap and placing another piece of filter fabric over the damaged area. All connecting joints should overlap a minimum of 1 foot. If the damage is extensive, replace the entire filter fabric.

4. Riprap may be placed by equipment but care should be taken to avoid damaging the filter.

5. The minimum thickness of the riprap should be 1.5 times the maximum stone diameter.

6. Construct the apron on zero grade with no overfall at the end. Level the top of the riprap at the downstream end with the receiving area or slightly below it.

7. Ensure that the apron is properly aligned with the receiving stream and preferably straight throughout its length. If a curve is needed to fit site conditions, it should be located in the upper section of the apron.

8. Immediately after construction, stabilize all disturbed areas with vegetation.

9. Select stone for riprap from field stone or quarry stone. The stone should be hard, angular, and highly weather resistant. The specific gravity of the individual stones should be at least 2.5.

10. Install a filter to prevent soil movement through the openings in the riprap. The filter should consist of a graded gravel layer or a synthetic filter cloth.

Maintenance

Inspect riprap outlet structures after heavy rains to determine if erosion has occurred around or below the riprap or if stones have been dislodged. Make needed repairs immediately to prevent further damage.

4.15 Surface Roughening

Su

Definition

Providing a rough soil surface with horizontal depressions created by operating a tillage or other suitable implement on the contour, or by leaving slopes in a roughened condition by not fine-grading them.

Purpose

Surface roughening is used for the following: (1) to aid in establishment of vegetative cover with seed, (2) to reduce runoff velocity and increase infiltration, and (3) to reduce erosion and provide for sediment trapping.

Conditions

All slopes steeper than 3:1 require surface roughening, either stair-step grading, grooving, furrowing, or tracking if they are to be stabilized with vegetation.

Areas with grades less steep than 3:1 should have the soil surface lightly roughened and loosened to a depth of 2 to 4 inches prior to seeding. Areas that have been graded and will not be stabilized immediately may be roughened to reduce runoff velocity until seeding is performed. Slopes with a stable rock face do not require roughening or stabilization.

Design Criteria

Graded areas with smooth, hard surfaces give a false impression of "finished grading" and a job well done. It is difficult to establish vegetation on such surfaces due to reduced water infiltration and the potential for erosion. Rough slope surfaces with uneven soil and rocks left in place may initially appear unattractive or unfinished, but will encourage water infiltration, speed the establishment of vegetation, and decrease runoff velocity.

Rough, loose soil surfaces provide lime, fertilizer, and natural coverage for seed. Niches in the surface provide microclimates that generally provide a cooler and more favorable moisture level than hard flat surfaces, which aids seed germination.

There are different methods of achieving a roughened soil surface on a slope, and the selection of an appropriate method depends upon the type of slope. Roughening methods include stair-step grading, grooving, and tracking. Factors to be considered in choosing a method are slope steepness, mowing requirements, and whether the slope is formed by cutting or filling.

1. Disturbed areas that will not require mowing may be stair-step graded, grooved, or left rough after filling.

2. Stair-step grading is particularly appropriate in soils containing large amounts of soft rock. Each "step' catches material that sloughs from above and provides a level site where vegetation can become established.

3. Areas that will be mowed (there areas should have slopes less steep than 3:1) may have small furrows left by disking, harrowing, raking, or seed planting machinery operated on the contour.

4. It is important to avoid excessive compacting of the soil surface when scarifying. Tracking with bulldozer treads is preferable to not roughening at all but is not as effective as other forms of roughening, as the soil surface is severely compacted and runoff is increased.

Construction Specifications

Cut slopes with a gradient steeper than 3:1 shall be stair-step graded or grooved (see Figures 4.15.1 and 4.15.2).

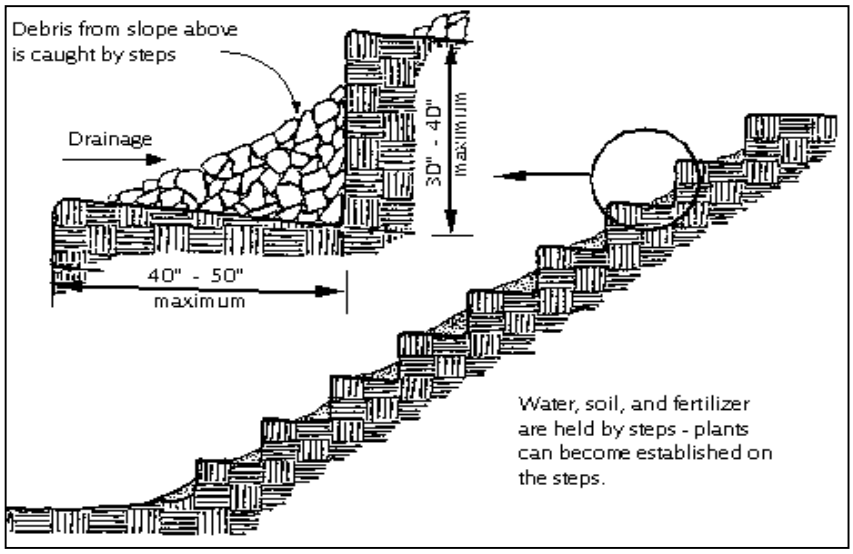


Figure 4.15.1 Stair-Stepping Cut Slopes

Stair-Step Grading

Stair step grading may be carried out on any material soft enough to be ripped with a bulldozer. Slopes consisting of soft rock with some subsoil are particularly suited to stair-step grading.

Figure 4.15.2 Typical Stair-Step Grading

The ratio of the vertical cut distance to the horizontal distance shall be less than 1:1 and the horizontal portion of the "step" shall slope toward the vertical wall.

Grooving

Grooving consists of using machinery to create a series of ridges and depressions, which run perpendicular to the slope (on the contour).

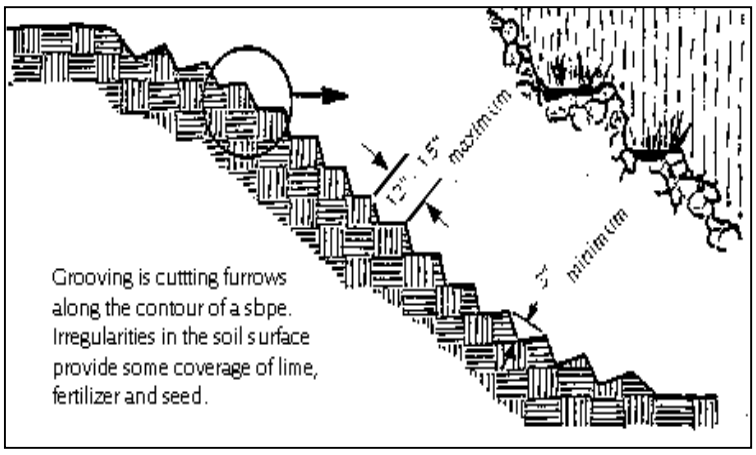


Figure 4.15.3 Grooving Slopes

Grooves may be made with any appropriate implement that can be safely operated on the slope and will not cause undue compaction. Suggested equipment includes discs, tillers, spring harrows, and the teeth on a front-end loader bucket. Grooves shall not be less than 3 inches deep nor further than 15 inches apart.

Fill Slope Applications for Areas That Will not be Mowed

Fill slopes with a gradient steeper than 3:1 shall be grooved or allowed to remain rough as they are constructed. Either of the following methods may be used.

1. Perform grooving as mentioned previously.

2. As lifts of the fill are constructed, soil and rock material may be allowed to fall naturally onto the slope surface.

Colluvial measures (soil deposits at the base of slopes or from old stream beds) shall not be used in fill as they flow when saturated.

Cuts, Fills, and Graded Areas That Will be Mowed

Mowed slopes should not be steeper than 3:1. Excessive roughness is undesirable where mowing is planned.

These areas may be roughened with shallow grooves by tilling, disking, harrowing, raking, or use of a multipacker-seeder. The final pass of any such tillage implement shall be on the contour (perpendicular to the slope).

Grooves formed by such equipment shall be not less than 1 inch deep and not further than 12 inches apart.

Fill slopes that are left rough as constructed may be smoothed with a dragline or pickchain to facilitate mowing.

Roughening With Tracked Machinery

Roughening with tracked machinery on clay soils is not recommended unless no alternatives are available. Undue compaction of surface soil results from this practice. Sandy soils do not compact severely and may be tracked. In no case is tracking as effective as the other roughening methods described.

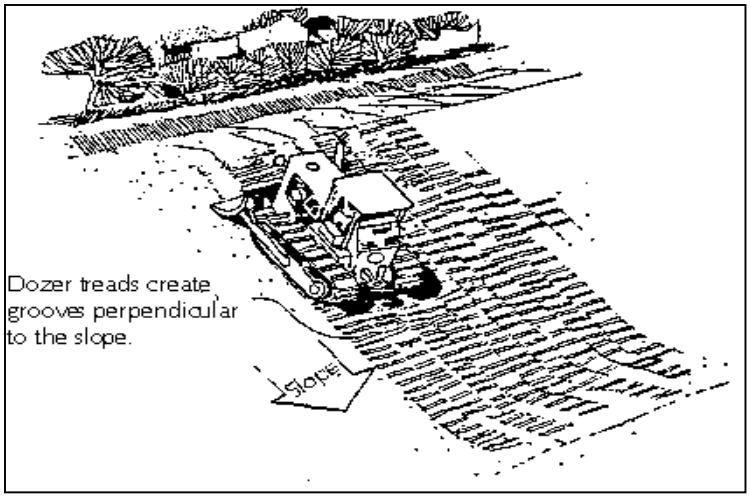


Figure 4.15.4 Roughening with tracked machinery.

When selected, tracking shall be performed by operating tracked machinery up and down the slope to leave horizontal depressions in the soil. As few passes of the machinery as possible should be made to minimize compaction.

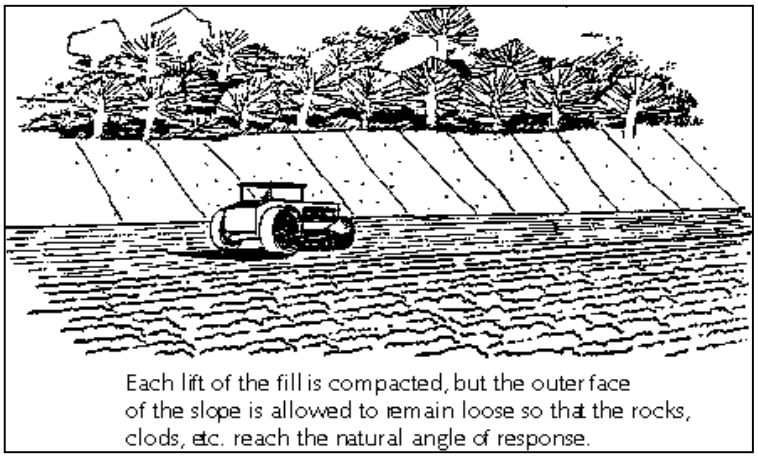


Figure 4.15.5 Fill slope treatment.

Seeding

Roughened areas shall be seeded and mulched as soon as possible to obtain optimum germination and seed growth.

4.16 Topsoiling

Tp

Definition

Stripping off the more fertile topsoil, storing it, then spreading it over the disturbed area after completion of construction activities.

Purpose

Topsoil is used to provide a suitable soil medium for vegetative growth on areas where other measures will not produce or maintain a desirable stand.

Conditions

This practice is recommended for sites of 2:1 or flatter slopes where:

- the texture of the exposed subsoil or parent material is not suitable to produce adequate vegetative growth,
- the soil material is so shallow that the rooting zone is not deep enough to support plans with continuing supplies of moisture and food, and
- the soil to be vegetated contains material toxic to plant growth.

Specifications

Materials

Topsoil should be friable and loamy, free of debris, objectionable weeds, and stones and should contain no toxic substance that may be harmful to plant growth. A pH range of 5.0 to 7.5 is acceptable. Soluble salts should not exceed 500 parts per million (ppm).

Testing

Field exploration should be made to determine whether the quantity or quality of surface soil justifies stripping.

Stripping

Stripping should be confined to the immediate construction area. A 4- to 6-inch stripping depth is common, but may vary depending on the particular soil.

Topsoil pH

If pH value is less than 6.0, lime shall be applied and incorporated with the topsoil to adjust the pH to 6.5 or higher. Topsoil containing soluble salts greater than 500 ppm shall not be used.

Stockpiles

The location of topsoil stockpiles should not obstruct natural drainage or cause off-site environmental damage. Stockpiles may be vegetated in accordance with the appropriate standards and specifications.

Site Preparation (Where Topsoil is to be Added)

Topsoiling

When topsoiling, maintain needed erosion control practices, such as diversions, grade stabilization structures, beams, dikes, level spreaders, waterways, and sediment basins.

Grading

Grades on the areas to be topsoiled that have been previously established.

Liming

Where the pH of the subsoil is 5.0 or less or composed of heavy clays, agricultural limestone shall be spread at the rate of 100 pounds per 1,000 square feet. Lime shall be distributed uniformly over designated areas and worked into the soil in conjunction with tillage operations as described in the following procedure.

Bonding

Use of the following methods to ensure bonding of topsoil and subsoil:

1. **Tilling.** After the areas to be topsoiled have been brought to grade, and immediately prior to dumping and spreading the topsoil, the subgrade shall be loosened by disking or scarifying to a depth of at least 3 inches to permit bonding of the topsoil to the subsoil.

2. **Tracking.** Passing a bulldozer over the entire surface area of the slope to leave tracks vertically or diagonally.

Applying Topsoil

Topsoil should be handled only when it is dry enough to work without damaging soil structure.

A uniform application of 5 inches (unsettled) is recommended, but may be adjusted at the discretion of the engineer or landscape architect.

Cubic Yards of Topsoil Required for Application to Various Depths

Depth (inches)	Per 1,000 Square Feet	Per Acre
1	3.1	134
2	6.2	268
3	9.3	403
4	12.4	537
5	15.5	672
6	18.6	806

4.17 Vegetated Waterway or Stormwater Conveyance Channel

Wt

Definition

A natural or constructed channel that is shaped or graded to required dimensions and established in suitable vegetation for the stable conveyance of runoff.

Purpose

Conveyance channels are used to dispose of runoff without causing damage by erosion or flooding.

Conditions

This standard applies to all sites where added channel capacity and/or stabilization is required to control erosion resulting from concentrated runoff and where such control can be achieved by this practice alone or in combination with others.

Design Criteria

Capacity

The minimum capacity shall be that required to convey the peak runoff expected from a 10-year, 24-hour storm or the storm specified. Peak runoff values used in determining the capacity requirements shall be by governing code or ordinance and by accepted engineering practices.

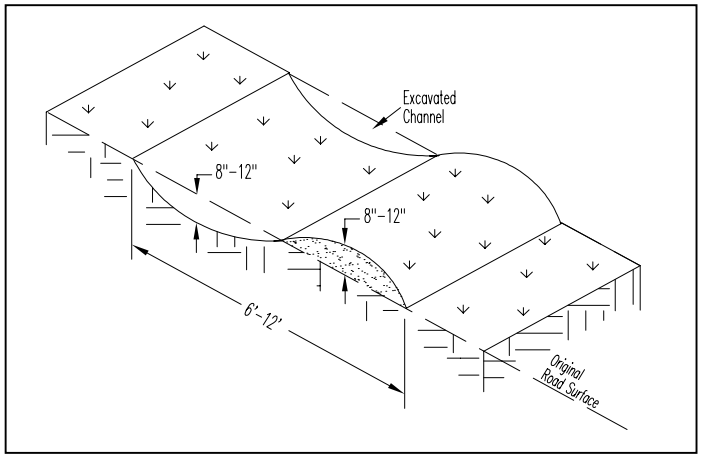


Figure 4.17.1 Typical Vegetated Waterway or Stormwater Conveyance Channel

The design of a waterway is based on determination of channel dimensions that will carry the estimated flow without damage to the channel of its liming. Vegetative linings vary in their protective ability according to type and density. Therefore, safe velocity under various conditions is a matter for careful consideration.

Velocity

In designing grassed waterways, care must be taken to ensure that the design velocity is well within the limits of permissible velocities for uniform good stands of each type of cover. Supporting documentation and calculations should be provided

Cross Section

The minimum design capacity of a waterway receiving water from developing areas, diversions, or other tributary channels shall be that depth required to keep the design water surface elevation in the channel to prevent overflow.

The bottom width of waterways or outlets shall not exceed 50 feet unless multiple or divided waterways or other means are provided to control meandering of low flows within this limit.

Drainage

Tile or other suitable subsurface drainage measures shall be provided for sites having high water tables or seepage problems. Where there is base flow, a stone center or lined channel will be required.

Stone Center

Stone center waterways, if necessary, shall be constructed as shown in Table 4.17.1 and stabilized with riprap according to applicable construction specifications. Stone size selection should be based on channel flow depth and velocity. Documentation and engineering calculations are to be provided.

TABLE 4.17.1

Permissible Velocities and Retardant Values for Vegetated Waterways

Vegetative Cover Type	For Capacity and V_2		For Stability and V_1		Maximum Permissible Velocity, V_1, fps
	Retardant Value	Plant Height (not mowed)	Retardant Value	Plant Height (mowed)	
Bermuda Grass	B	12 inches	D	2-6 inches	5
Bahia	C	6-12 inches	D	2-6 inches	4
Tall Fescue Grass Mixtures*	B	18 inches	D	6 inches	3
Sericea Lespedeza Weeping Lovegrass	B	18 inches	D	2-6 inches	3

*Mixtures of Tall Fescue, Bahia, and/or Bermuda

Note: For planting instructions, refer to Disturbed Area Stabilization (with permanent vegetation) Ds3.

Vegetative Retardant Factor

The design of a vegetated waterway is more complicated than for a bare channel since the value for "n" varies where grass linings are used. Analyses show that vegetation tends to bend and oscillate under the influence of velocity and depth of flow; thus flow-retardant values vary as these factors change.

Five general retardant curves designated A, B, C, D, and E have been developed for various cover conditions. The vegetal conditions under which the various retardant values apply are shown in Table 4.17.1. These cover classifications are based on tests in experimental channels when the covers were green and generally uniform. Professional engineering assistance is recommended. Publication SCS-TP-61 by the Soil Conservation Service is a useful reference.

TABLE 4.17.2

Velocity, Top Width and Depth for Parabolic Stone Center Waterways

	Grade 6	Percent	Grade 8	Percent	Grade 10	Percent	Grade 12	Percent	Grade 15	Percent
V	8.0	10	8.0	10	8.0	10	8.0	10	8.0	10
D	1.3	1.6	1.1	1.3	1.0	1.2	0.9	1.1	0.8	0.9
Q	Top Widths									
20							5		5	
25					5		6		6	4
30			5		6		7		7	5
35			6		7		8	5	8	6
40	6		7		8	5	9	6	10	7
45	7		8		9	6	10	6	11	7
50	7		9	6	10	7	11	7	12	8
55	8		9	6	11	7	12	8	13	9
60	9		10	7	12	8	13	8	14	9
65	9		11	7	12	9	14	9	16	11
70	10	7	12	8	13	9	15	10	17	11
75	11	7	13	9	14	10	16	10	18	12
80	12	8	14	9	15	10	18	11	19	13
90	13	9	15	10	17	12	20	13	21	15
100	14	10	17	11	19	13	22	14	24	16
110	16	11	19	13	21	14	24	15	26	18
120	17	11	21	14	23	16	26	17	29	20
130	19	12	22	15	25	17	29	18	31	21
140	20	13	24	16	27	18	31	19	33	23
150	22	14	26	17	29	20	33	21	36	24
160	23	15	27	18	31	21	35	22	38	26
170	25	16	29	19	33	22	37	24	40	28
180	26	17	31	20	34	23	39	25	43	29
190	27	18	32	22	36	25	42	26	45	31
200	29	19	34	23	38	26	44	28	47	33
220	32	21	38	25	42	29	48	31	52	38
240	35	23	41	27	46	31	53	33	57	39
260	38	25	44	30	50	34	57	36	62	42
280	40	27	48	32	54	36	61	39	67	45
300	43	29	51	34	57	39	66	42	71	49

Construction Specifications

1. All trees, brush, stumps, obstructions, and other objectionable material should be removed and disposed of so as not to interfere with the proper functioning of the waterway.

2. The waterway or outlet should be excavated or shaped to line, grade, and cross section as required to meet the criteria specified herein. It will be free of bank projections or other irregularities, which will impede normal flow.

3. Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the completed waterway.

4. All earth removed and not needed in construction shall be spread or disposed so that it will not interfere with waterway functioning.

5. Applicable vegetative standards shall be followed for time of seeding, sprigging or sodding, liming and fertilizing, and site and seedbed preparation.

   Mulching shall be a requirement for all seeded or sprigged channels and shall be performed according to "Disturbed Areas Stabilization (With Mulching Only)."

Temporary protection during establishment should be provided when conditions permit through temporary diversions or other means to dispose of water. Erosion control fabrics designed to protect seed and slopes during the establishment of vegetation may also be used. These fabrics hold seed and soil in place to prevent erosion while the seed is germinating and until a vegetative cover is established. The fabric is constructed from a natural fiber that is biodegradable and will add organic matter to the soil upon decomposition. Installation methods should follow manufacturer recommendations.

4.18 Buffer Zone

Bf

Definition

A strip of undisturbed, original land or vegetation surrounding the land-disturbed site or bordering streams.

Purpose

Buffer zones serve one or more of the following purposes:

- Reduce storm runoff velocities.
- Filter sediment in runoff water.
- Act as screen for "vision pollution."
- Reduce construction noise.
- Improve aesthetics on the land disturbed.

Conditions

Typically, a natural strip of vegetation should be preserved and, if needed, supplemented to form the buffer zone. Buffer zone requirements are specified by state code or local ordinance, i.e., Chattanooga Landscape Ordinance 10692.

Where necessary, a buffer zone may be installed using the Vegetative Practices included in this manual. In most cases, the buffer zone will be incorporated into the permanent vegetative cover.

Design Conditions

A width should be selected to permit the zone to serve the purpose(s) listed above. Supplemental plantings may be used to increase the effectiveness of the buffer zone.

4.19 Disturbed Area Stabilization (with Mulching Only)

Ds1

Definition

Applying plant residues or other suitable materials not produced on the site to the soil surface.

Purpose

Mulching is used for the following:

- To reduce runoff and erosion.
- To conserve moisture and prevent surface compaction or crusting.
- To control undesirable vegetation.
- To modify soil temperature.
- To increase biological activity in the soil.

Specifications

Temporary Protection Without Seeding

This standard applies to grades or cleared areas that may be subjected to erosion for 6 months or less, where seedings may not have a suitable growing season to produce an erosion-retardant cover but can be stabilized with a mulch cover.

Site Preparation

1. Grade as needed to permit the use of equipment for applying and anchoring mulch.

2. Install erosion control measures as required such as dikes, diversions, berms, terraces, and sediment barriers.

3. Loosen compact soil to a minimum depth of 3 inches as needed.

Mulching Materials

1. Dry straw or hay – spread at a rate of 2½ tons per acre.

2. Wood waste, chips, sawdust, or bark – spread 2 to 3 inches deep (6 to 9 tons per acre).

3. Erosion control matting or netting, such as excelsior, jute, textile, and plastic matting and netting – applied in accordance with manufacturer's recommendations.

4. Cutback asphalt, slow curing – applied at 1,200 gallons per acre (or ¼ gallon per square yard).

5. Polyethylene film – secured over banks or stockpiled soil material for temporary protection.

Applying and Anchoring Mulch

1. Apply straw or hay mulch uniformly by hand or mechanically. Anchor mulch as appropriate and feasible. Mulch may be pressed into the soil with a disk harrow with the disk set straight or with a special "packer disk." The disk may be smooth or serrated and should be 20 inches or more in diameter and 8 to 12 inches apart. The edges of the disk should be dull enough to avoid cutting the mulch as it is pressed into the soil in an erect position.

   Straw or hay that is spread with special blower-type equipment may be anchored with emulsified asphalt (Grade AE-5 or SS-1). The asphalt emulsion must be sprayed onto the mulch as it is ejected from the machine. Use 100 gallons of water per ton of mulch.

2. Wood waste should be spread uniformly on slopes that are 3:1 and flatter. No anchoring is needed.

3. Commercial matting and netting. Follow manufacturer's specification included with the material.

4. Apply asphalt so area has uniform appearance. (Note: Use in areas of pedestrian traffic could cause problems of "tracking in" or damage to shoes, clothing, etc.)

Conserve Moisture and Control Weeds

Mulching can also be used to conserve moisture and control weeds in nurseries, ornamental beds, around shrubs, and on bare areas on lawns.

Mulching Materials

Use one of the materials given below and apply at thickness indicated:

	Materials	Depth (inches)
1.	Grain straw or grass hay	6 to 10
2.	Pine needles	4 to 6
3.	Wood waste (sawdust, bark, chips)	4 to 6
4.	Shredded residues (crops, leaves, etc)	4 to 8

Completely cover area with suitable (porous) geotextile fabric. When using organic mulches, apply 20 to 30 pounds of nitrogen in addition to the normal amount needed for plant growth to offset the tie up of nitrogen (N) by decomposition of mulch.

4.20 Disturbing Area Stabilization (With Temporary Seeding)

Ds2

Definition

Establishing temporary vegetative cover with fast-growing seedlings on disturbed or denuded areas.

Purpose

Temporary seeding is used for the following:

- to reduce erosion, sediment, and runoff damages to downstream resources,
- to improve wildlife habitat,
- to improve aesthetics,
- to improve safety and public road rights-of-way, and
- to improve tillage and add organic matter for permanent plantings.

Conditions

This practice is applicable on areas subject to erosion for up to 12 months or until establishment of finished grade or permanent vegetative cover. Temporary vegetative measures should be coordinated with permanent measures to assure economical and effective stabilization.

Specifications

Prior to seeding, install necessary erosion control practices such as dikes, waterways, and basins.

Seedbed Preparation

To control erosion on bare soil surfaces, plants must be able to germinate and grow. Seedbed preparation is essential.

Liming

Where soils are known to be highly acidic (pH 5.5 and lower), lime should be applied at the rate of 2 tons of pulverized agricultural limestone per acre.

Fertilizer

Fertilizer shall be applied as 450 lbs./acre of 10-20-20 (10 lbs./1,000 square feet) or equivalent. Lime and fertilizer shall be incorporated into the top 2 to 4 inches of the soil.

Surface Roughening

If the area has been recently loosened or disturbed, no further roughening is required.

When the area is compacted, crusted, or hardened, the soil surface shall be loosened by discing, raking, harrowing, or other acceptable means. See surface roughening.

Tracking

Tracking with bulldozer cleats is most effective on sandy soils. This practice often causes undue compaction of the soil surface, especially in clayey soils, and does not aid plant growth as effectively as other methods of surface roughening.

Seeding

Seed shall be evenly applied with a cyclone seeder, drill, cultipacker seeder, or hydroseeder. Small grains shall be planted no more than 1 inch deep. Grasses and legumes shall be planted no more than ¼ inch deep. See Table 4.21.1 for seed recommendations.

Mulching

1. Seeding operations made in fall for winter cover shall be mulched.

2. At other times of the year, seeding on slopes in excess of 4:1, or on adverse soil conditions, or during excessively hot or dry weather, shall be mulched.

3. Seeding operations made during optimum spring and summer seeding dates, with favorable soil and site conditions, will not require mulch.

Reseeding

Areas that fail to establish vegetative cover adequate to prevent rill erosion will be re-seeded as soon as identified.

TABLE 4.21.1

Seeding Mixtures, Rates and Dates

Site Conditions	Seeding Mixtures	Rates		Dates		
		Per Acre	Per 1,000 ft²	3/15 to 5/1	5/1 to 8/15	8/15 to 10/1
High Maintenance Lawns	1. Kentucky bluegrass—a blend of 4 or more varieties ..... 100% (No variety shall be more than 30% of total mixture.) Note: Up to 50% of the mixture may be red Fescue, where lawns are shaded	140 lbs	3 lbs	X	No	X
	2. Tall Fescue ..... 80% Kentucky Bluegrass (Kenblue or So. Dakota Cert.) ..... 10% NOTE: May also be used on low maintenance lawns	200 lbs	6 lbs	X	No	X
Low Maintenance General Use	3. Tall Fescue ..... 50% Ladino clover ..... 10% Red clover ..... 10% Korean lespedeza ..... 15% Annual ryegrass 15%	80 lbs	2 lbs	X	(a,b) X	X
	4. Tall Fescue ..... 50% Sericea lespedeza ..... 30% Annual ryegrass ..... 15% Redtop 5%	70 lbs	1½ lbs	X	(a)X	X
Slopes	5. Crown vetch ..... 50% Perennial ryegrass ..... 40% Redtop 10%	40 lbs	1 lbs	X	No	X
	6. Flat pea ..... 50% Tall Fescue 50%	80 lbs	2 lbs	X	No	X
Droughty Areas	7. Tall Fescue ..... 65% Reed canarygrass ..... 20% Annual ryegrass 15%	80 lbs	2 lbs	X	No	X
	Tall Fescue ..... 60% Sericea lespedeza ..... 30% Redtop 10%	70 lbs	1½ lbs	X	(a)X	X

a. After May 15, use 10 lbs /A German millet or 2 lbs /A weeping lovegrass in place of

annual ryegrass or Redtop.
b. After May 15. Omit Korean lespedeza and increase red clover to 20% of mixture.

4.21 Permanent Seeding

Ds3

Definition

The establishment of perennial vegetative cover on disturbed areas by planting seed.

Purposes

Permanent seeding is used to reduce erosion and decrease sediment yield from disturbed areas and to permanently stabilize disturbed areas in a manner that is economical, adaptable to site conditions, and allows selection of the most appropriate plant materials.

Conditions

Permanent shall be performed in disturbed areas where permanent, long-lived vegetative cover is needed to stabilize the soil and in rough-graded areas that will not be brought to final grade for 1 year or more.

Planning Considerations

Vegetation controls erosion by reducing the velocity and the volume of overland flow and protecting the bare soil surface from raindrop impact. Areas that must be stabilized after the land has been disturbed require vegetative cover. The most common and economical means of establishing this cover is by seeding grasses and legumes.

Advantages of seeding over other means of establishing plants include the small initial establishment cost, the wide variety of grasses and legumes available, low labor requirement, and ease of establishment in difficult areas.

Disadvantages include the potential for erosion during the establishment stage, a need to reseed areas that fail to establish, limited periods during the year suitable for seeding, and a need for water and appropriate climatic conditions during germination.

There are so many variables in plant growth that an end product cannot be guaranteed. Much can be done during the planning stages to increase the chances for successful seeding. Selection of the right plant materials for the site, good seedbed preparation, and conscientious maintenance are important.

Soils can be modified with lime and fertilizer, but climate cannot be controlled. Microclimate, or localized climate conditions, can affect plant growth. A south-facing slope is dried and hotter than a north-facing slope and may require drought-tolerant plants. Shaded areas require shade-tolerant plants; the windward side of a ridge will be drier than the leeward, etc.

A prime consideration in selecting which plants to establish is the intended use of the land. All of these uses—residential, industrial, commercial, and recreational—can be separated into two categories: high maintenance and low maintenance.

High-maintenance areas will be mowed frequently, lime and fertilized regularly, and will wither receive intense use (e.g., athletics) or require maintaining to an aesthetic standard (home lawns). Grasses used for these situations must be fine-leafed and attractive in appearance, able to form tight sod, and be long-lived perennials. They must be well adapted to the geographic area where they are planted, because constant mowing puts turf under great stress. Sites where high-maintenance vegetative cover is desirable include homes, industrial parks, schools, churches, and some recreational areas.

Low-maintenance areas will be mowed infrequently or not at all; lime and fertilizer may not be applied on a regular basis; the areas will not be subjected to intense use, nor required to have a uniform appearance. These plants must be able to persist with little maintenance over long periods of time. Grass and legume mixtures are favored for these sites because legumes are capable of fixing nitrogen from the are for their own use, and the use of the plants around them. Such mixed strains are better able to withstand adverse conditions. Sites that would be suitable for low-maintenance vegetation include steep slopes, stream or channel banks, some commercial properties, and “utility turf” areas such as roadbanks.

Seedbed Preparation

The soil on disturbed site must be modified to provide an optimum environment for seed germination and seedling growth. The surface soil must be loose enough for water infiltration and root penetration. The pH (acidity and alkalinity) of the soil must be such that it is not toxic and nutrients are available, usually between pH 6.0-7.0. Sufficient nutrients—added as fertilizer—must be present. After seed is in place, it must be protected with mulch to hold moisture and modify temperature extremes, and to prevent erosion while seedlings are growing.

The addition of lime is equally as important as applying fertilizer. Lime is best known as a pH, or acidity modifier, but it also supplies calcium and magnesium which are plant nutrients. Its effect on pH makes other nutrients more available to the plant.

Maintenance

Even with careful, well-planned seeding operations, failures can occur. When it is clear that plants have not germinated on an area or have died, these areas must be reseeded immediately to prevent erosion damage. Healthy vegetation is the most effective erosion preventive available.

Seedbed Requirements

Vegetation should not be established on slopes that are unsuitable due to inappropriate soil texture, poor internal structure or internal drainage, volume of overland flow, or excessive steepness, until measures have been taken to correct these problems.

To maintain a good stand of vegetation, the soil must meet certain minimum requirements as a growth medium. The existing soil must have these criteria:

1. Enough fine-grained material to maintain adequate moisture and nutrient supply.

2. Sufficient pore space to permit root penetration. A bulk density of 1.2 to 1.5 indicates that sufficient pore space is present. A fine granular or crumb-like structure is also favorable.

3. Sufficient depth of soil to provide an adequate root zone. The depth to rock or impermeable layers such as hardpans shall be 12 inches or more, except on slopes steeper than 2:1 where the addition of soil is not feasible.

4. A favorable pH range for plant growth. If the soil is so acid that a pH range of 6.0–7.0 cannot be attained by addition of pH-modifying materials, then the soil is considered an unsuitable environment for plant roots.

5. Freedom from toxic amounts of materials harmful to plant growth.

6. Freedom from excessive quantities of roots, branches, large stones, large clods of earth, or trash of any kind. Clods and stones may be left on slopes steeper than 3:1 if they are to be hydroseeded.

Necessary mechanical erosion and sediment control practices will be installed prior to seeding. Grading will be carried out according to the approved plan.

Surfaces will be roughened in accordance with "Surface Roughening."

Soil Conditioners

In order to modify the texture, structure, or drainage characteristics of a soil, the following materials may be added to the soil:

1. **Peat** shall be sphagnum moss peat, hypnum moss peat, reed-sedge peat or peat humus, from fresh-water sources. Peat shall be shredded and conditioned in storage piles for at least six months after excavation.

2. **Sand** shall be clean and free of toxic materials.

3. **Vermiculture** shall be horticultural grade and free of toxic substances.

4. **Rotted manure** shall be stable or cattle manure not containing undue amounts of straw or other bedding materials or toxic chemicals.

5. **Thoroughly rotted sawdust** shall have 6 pounds of nitrogen added to each cubic yard and shall be free of stones, sticks, and toxic substances.

Lime and fertilizer shall be incorporated into the top 4 to 6 inches of the soil by discing or other means. When applying lime and fertilizer with a hydroseeder, apply to a rough, loose surface.

Seeding

1. Certified seed will be used for all permanent seeding whenever possible.

2. Legume seed should be inoculated with the inoculant appropriate to the species. Seed of lespedezas, crown vetch, and clovers should be scarified to promote uniform germination.

3. Apply seed uniformly with a cyclone seeder, drill, cultipacker seeder, or hydroseeder on a firm, friable seedbed. Maximum seeding depth should be ¼ inch.

4. To avoid seed damage during hydroseeding, it is recommended that if the machinery breaks down for ½ to 2 hours, 50 percent more seed be added to the

tank, based on the proportion of the slurry remaining in the tank. Beyond 2 hours, a full rate of new seed may be necessary.

Often hydroseeding contractors prefer not to apply lime in their rigs as it is abrasive. In inaccessible areas, lime may have to be applied in pellet or liquid form, separately. Rates of wood fiber should be at least 2,000 lbs. per acre. Surface roughening is particularly important when hydroseeding, as a roughened slope will provide some natural coverage of lime, fertilizer and seed.

5. Legume inoculants should be applied at four times the recommended rate when inoculant is included in the hydroseeder slurry.

Mulching

All permanent seed must be mulched immediately upon completion of see application.

Maintenance of New Seed

Irrigation

New seed should be supplied with adequate moisture. Supply water as needed, especially late in the season, in abnormally hot or dry weather, or on adverse sites. Water application rates should be controlled to prevent runoff. Inadequate amounts of water may be more harmful than no water.

Reseeding

Inspect seeded areas for failure and make necessary repairs and reseed within the same season, if possible.

If vegetative cover is inadequate to prevent rill erosion, overseed and fertilize in accordance with soil test results.

If a stand has less than 40 percent cover, reevaluate choice of plant materials and quantities of lime and fertilizer. Reestablish the stand following seedbed preparation and seeding recommendations, omitting lime and fertilizer in the absence of soil test results. If vegetation has failed to grow, soil must be tested to determine if acidity or nutrient imbalances are responsible.

Fertilization

Seedlings should be fertilized 1 year after planting to ensure proper stand density.

Generally, a stand of vegetation cannot be determined fully established until soil cover has been maintained for 1 full year from planting. Disturbed areas to be stabilized with permanent vegetation must be seeded or planted within 15 days after final grade is reached unless temporary stabilization is applied.

4.22 Disturbed Area Stabilization (Sodding)

Ds4

Definition

Stabilizing fine-graded disturbed areas by establishing permanent grass stands with sod.

Purposes

Sodding is used for the following:

1. to establish permanent turf immediately,
2. to prevent erosion and damage from sediment and runoff by stabilizing the soil surface,
3. to reduce the production of dust and mud associated with bare soil surfaces, and
4. to stabilize drainage ways where concentrated overload flow will occur.

Conditions

Sodding should be applied under the following conditions:

1. Disturbed areas that require immediate vegetative covers or where sodding is preferred to other means of grass establishment.

2. Locations particularly suited to stabilization with sod, including:

   - Waterways carrying intermittent flow
   - Areas around drop inlets in grassed swales
   - Residential or commercial lawns where quick use or aesthetics are factors

Planning Considerations

The successful establishment of quality turf grass is difficult. Extremes in temperature and moisture availability create severe stresses on both cool and warm season grasses. The selection of appropriate turf-establishment methods requires a great deal of forethought.

A quality turf containing the recommended mixtures and species can be established with either seed or sod. Soil preparation for the two methods is the same.

The advantages of properly installed sod include:

- Immediate erosion control.
- An instant green surface with no dust or mud.
- Nearly year-round establishment capability.
- Less chance of failure than with seed.
- Freedom from weeds.
- Quick use of the sodded surface.
- The option of buying a quality-controlled product with predictable results.

It is initially more costly to install sod than to seed. However, this cost is justified in places where sod can perform better than seed in controlling erosion.

In swales and waterways where concentrated flow will occur, properly pegged sod is preferable to seed because there is no lag time between installation and the time when the channel is protected by vegetation.

Drop inlets to be placed in grassed areas can be kept free of mulch, seed, and mud, and the grade immediately around the inlet can be maintained, by framing the inlet with sod strips.

As long as adequate water is available for irrigation in the early weeks, sod can be laid during times of the year when seeded grass may fail.

Ground preparation and proper maintenance are also important with sod. Sod is composed of living plants and those plants must receive adequate care in order to provide vegetative stabilization on a disturbed area.

Specifications

Soil Preparation

1. Prior to soil preparation, areas to be sodded shall be brought to final grade in accordance with the approved plan.

2. Soil tests should be made to determine the exact requirements for lime and fertilizer.

   Under difficult circumstances where it is not possible to obtain a soil test, the following soil amendments shall be made:

   - Pulverized agricultural limestone at 100 pounds per 1,000 square feet (2 tons per acre). Note: Only carbonate forms of lime may be used.

   - Fertilizer at 25 pounds per 1,000 square feet (1,000 lbs./acre) of 10-10-10 in fall or 25 pounds per 1,000 square feet of 5-10-10 in spring. Note: Equivalent nutrition may be applied with other fertilizer formulations.

   These amendments shall be spread evenly over the area to be sodded, and incorporated into the top 3 to 6 inches of soil by discing, harrowing or other acceptable means.

3. Prior to laying sod, the soil surface shall be clear of trash, debris, roots, branches, stones, and clods in excess of 2 inches in length or diameter. Sod shall not be applied to gravel or other non-soil surfaces.

4. Any irregularities in the soil surface resulting from topsoil or other operations shall be filled or leveled in order to prevent the formation of depressions of toxic materials.

Quality of Sod

1. Sod shall be machine cut at a uniform soil thickness of ¾-inch, plus or minus ¼-inch, at the time of cutting. Thickness shall exclude shoot growth and thatch.

2. Pieces of sod shall be cut to the supplier's standard width and length, with a maximum allowable deviation in any dimension of 5 percent. Torn or uneven pads should not be used.

3. Standard size sections of sod shall be strong enough to support their own weight and retain their size and shape when suspended from a firm grasp on one end of the section.

4. Sod shall not be cut or laid in excessively wet or dry weather.

5. Sod should be harvested, delivered, and installed within a period of 36 hours.

Sod Installation

1. Sod should not be laid on soil surfaces that are frozen.

2. During periods of high temperature, the soil shall be lightly irrigated immediately prior to laying the sod, to cool the soil and reduce root burning and dieback.

3. The first row of sod shall be laid in a straight line with subsequent rows placed parallel to and butting tightly against each other. Lateral joints shall be staggered to promote more uniform growth and strength. Care shall be exercised to ensure that sod is not stretched or overlapped and that all joints are butted tight in order to prevent voids that would cause drying of the roots.

4. On slopes 3:1 or greater, or wherever erosion may be a problem, sod shall be laid with staggered joints and secured by pegging or other approved methods. Sod shall be installed with the length perpendicular to the slope (on the contour).

5. As sodding of clearly defined areas is completed, and sod shall be rolled or tamped to provide firm contact between roots and soil.

6. After rolling, sod shall be irrigated to a depth sufficient that the underside of the sod pad and the soil 4 inches below the sod is thoroughly wet.

7. During the first week, in the absence of adequate rainfall, watering shall be performed as often as necessary to maintain moist soil to a depth of at least 4 inches.

8. The first mowing shall not be attempted until the sod is firmly rooted, usually 2 to 3 weeks. Not more than one-third of the grass leaf shall be removed at any one cutting.

Sodded Waterways

1. Care should be taken to prepare the soil adequately in accordance with this specification. The sod type shall consist of plant materials able to withstand the designed velocity.

2. Sod strips in waterways shall be laid perpendicular to the direction of flow. Care should be taken to butt ends of strips tightly.

3. After rolling or tamping, sod shall be pegged or stapled to resist washout during the establishment period. Chicken wire, jute, or other netting may be pegged over the sod for extra protection in critical areas.

4. All other specifications for this practice shall be adhered to when sodding a waterway.

Maintenance of Established Sod

1. After the first week, sod shall be watered as necessary to maintain adequate moisture in the root zone and prevent dormancy of sod.

2. No more than one-third of the shoot (grass leaf) should be removed in any mowing. Grass height should be maintained between 2 and 3 inches unless otherwise specified.

3. After the first growing season, established sod will require fertilization and may require lime. Follow soil-testing recommendations when possible, or use the rates indicated below.

Maintenance Fertilization of Established Sod with 20-10-10
(Equivalent amounts of nutrients may be applied with other formulations.)

	Kentucky-31 Tall Fescue		Kentucky Bluegrass		Bermuda Grass	
Grasses	lb/Acre	lb/1000 sf	lb/Acre	lb/1000 sf	Lb/Acre	lb/1000 sf
September	250	6	250	6	-	-
October	250	6	250	6	-	-
December	250	6	250	6	-	-
May	-	-	-	-	200	5
June	85*	2	85*	2	-	-
July	-	-	-	-	200	5
August	-	-	-	-	200	5

*Only if there is an obvious need for fertilizer at this time.

4.23 Dust Control on Disturbed Areas

Du

Definition

Controlling surface and air movement of dust on construction sites, roads, and demolition sites.

Purpose

Dust control prevents surface and air movement of dust from exposed soil surfaces to reduce the presence of airborne substances that may be harmful or injurious to human health and the welfare of animals or plant life.

Conditions

This practice is applicable to areas subject to surface and air movement of dust where on- and off-site damage may occur without treatment.

Temporary Methods and Materials

Mulches

See section "Disturbed Area Stabilization (With Mulching Only)." Synthetic resins may be used instead of asphalt to bind mulch material. Resins such as Curasol or Terratack should be used according to manufacturer's recommendations.

Vegetative Cover

See section "Disturbed Area Stabilization (With Temporary Seeding)."

Spray-On Adhesives

These are used on mineral soils (not effective on muck soils). Keep traffic off these areas. See Table 4.23.1.

TABLE 4.23.1

Emulsion Application Rates

Adhesive	Water Dilution	Type of Nozzle	Application Rate (gallons/acre)
Anionic Asphalt Emulsion	7:1	Coarse Spray	1,200
Latex Emulsion	12½:1	Fine Spray	235
Resin-in-Water Emulsion	4:1	Fine Spray	300

Tillage

This practice is designed to roughen and bring clods to the surface. It is an emergency measure that should be used before wind erosion starts. Begin plowing on windward wide of site. Chisel-type plows spaced approximately 12 inches apart, spring-toothed harrows, and similar plows are examples of equipment that may produce the desired effect.

Irrigation

This is generally done as an emergency treatment. Site is sprinkled with water until the surface is wet. Repeat as needed.

Barriers

Solid board fences, snow fences, burlap fences, crate walls, bales of hay and similar material can be used to control air currents and soil blowing. Barriers placed at right angles to prevailing currents at intervals of approximately 15 times their height are effective in controlling wind erosion.

Calcium Chloride

Apply at a rate that will keep surface moist. May need to be retreated.

Permanent Methods and Materials

Permanent Vegetation

See section “Disturbed Area Stabilization.” Existing trees and large shrubs may afford valuable protection if left in place.

Topsoiling

This entails covering the surface with less erosive soil material. See section "Topsoiling."

Stone

Cover surface with crushed stone or coarse gravel.

Appendix A

Chattanooga Stormwater Management Ordinances

Appendix B

Chattanooga Landscape Ordinance

Appendix C

Participating Local Community Stormwater Ordinances